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TEACHING CHEMISTRY IN THE LABORATORY.*

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In the year 1872 a young man was called to the chair of chemistry in a well-known Eastern college. He possessed to a remarkable degree the ability of interesting his pupils in his subject, and one of his students, becoming fascinated by the classroom discussions, asked permission to enter the laboratory in order that he might for himself become acquainted with the experimental side of the subject. So unusual was the request that it was found necessary to refer the matter to the college faculty, which after due deliberation replied it would not be feasible to grant such a request because the young man in his inexperience would quite certainly break valuable glassware and use up expensive chemicals. An inventory of American universities and colleges of that period reveals the fact that there were only six of the most progressive institutions of the country which were equipped with chemical laboratories to which students were admitted. In all the other institutions, if chemistry were offered at all it was as a purely classroom exercise.[1]

In the forty-six years which have elapsed since this simple incident took place, the young college professor has come to be recognized as one of America's foremost chemists and educators. That he is still active as an earnest searcher after scientific truth merely emphasizes the shortness of the intervening years. Yet within the active career of this one teacher, what a change has come over our methods of teaching chemistry! Today not

*Read before the Chemistry Section of the C. A. S. & M. T. at the University of Chicago, November 30, 1918.

[1]For a description of the sort of science instruction given in American colleges of this period, see the interesting article on "Laboratory Teaching," by President Eliot, in School Science and Mathematics, Vol. 6, November, 1906.

only every university and college but nearly every high school the country over, boasts of its chemical laboratory and its facilities for teaching the esperimental facts of the science. The advance has been general and so rapid that there is small wonder at the lack of uniformity and bewildering array of pedagogical theories and "methods" of instruction for laboratory teaching. Under such conditions a paper, entitled, "Teaching Chemistry in the Laboratory," might be expected to present some new theories, or some original plan of operation, or at least some method which has become a hobby. The present effort will not concern itself with any of the various theories concerning laboratory instruction, however interesting and valuable they may be. The present desire is to show how successful laboratory instruction may be an accomplished fact and to recall the importance of such work.

Most of the elementary textbooks attempt to give in their introductory chapter a definition of chemistry or a statement of what sort of phenomena the beginner may expect to find in the new subject. It is interesting to compare these statements of the various authors. With striking regularity they emphasize the experimental nature of the work as may be seen by considering two typical cases: (1) "The study of substances and their properties is the particular field of chemistry." (2) "It is the function of the chemist to investigate the action of each substance on every other, and to study the properties of the combinations resulting from this action." From ten elementary books which were easily accessible, statements similar to these were taken, while only one mentions the fact that chemistry deals also with laws and theories as well as certain manufacturing interests. Thus it appears that to the authors of our textbooks the subject of chemistry is almost wholly experimental in its nature, since its chief concern is to study the properties of substances and the changes in those properties which may be brought about by chemical means. If this is a true conception of chemistry and its province, then it must follow of necessity that the most important part of our chemical teaching must be done in the laboratory, since it is there and there only that we study substances, properties, and chemical changes. In the recitation room we may talk *about* some object, property, or change, but in the laboratory we see and handle the substance, test its properties, and observe the changes which it is capable of undergoing. Our efforts in the lecture and recitation room

are more or less indefinite, abstract, confusing, or even misleading, since we are talking about things more or less remote, while in the laboratory the study should be definite, concrete, and illuminating.

It is necessary to add hurriedly that the instruction in the recitation room is a fundamentally important part of chemical teaching and must be carried along faithfully and thoroughly. But the argument here presented is that instruction in the quiz room is *about* chemistry, while in the laboratory the inquiring mind is really studying chemistry itself. The former is necessary to systematize and correlate facts gleaned in the laboratory, while the latter should be the real backbone of the course.

When laboratory instruction was first introduced into our educational system it was considered a sort of scientific supervised play, a kind of busy work to fill up time or at best a means of illustrating certain facts which had already been "learned" from the textbook. It is to be regretted that this viewpoint has by no means disappeared even among teachers of chemistry themselves. But I believe that it is no longer possible for a teacher to give satisfactory instruction in the laboratory when he regards his duty as that of a monitor; or as a dispenser of supplies; or as an agent of the Red Cross to care for the unfortunate bungler; or even as an encyclopedia of ready information to answer a perfect torrent of questions of all sorts. The successful teacher in the laboratory must teach, which, according to Webster, means "to show, guide, counsel," "to make to know how," "to direct as an instructor." There is no better place anywhere in our educational system to "educate" than in the chemical laboratory. For there the teacher must literally "draw out" the meaning of the experiments and develop the ability to observe, to reason, and to think.

This end, which comes close to representing the purpose of all education, can doubtless be obtained in many ways, but the only successful methods which have come to the notice of the writer involve careful individual attention to each pupil in the class. Watchfulness and opportune suggestions are necessary during the process of setting up a piece of apparatus, during the carrying out of the experiment, but most especially after the experiment is completed and the record made in the notebook. It seems to be an undebatable axiom that the more promptly the students' conclusions are reviewed by the teacher, the more willingly will mistakes be corrected and the more clearly will

the point of the experiment be understood. In our work we have found it extremely beneficial to have the teacher pass around his class, examining notebooks, inspecting work that is in progress, and above all asking questions upon various points of the work. We have found it impossible to depend solely upon the student's written record, for the reason that frequently he may be able to write an acceptable record of an experiment which in reality he does not comprehend. A few judicious questions will reveal the thoroughness of his understanding and the amount of real thought which he has put into his work. Frequently the questioning may extend to points quite beyond the purpose of any given experiment, in order to cultivate the pupil's power of observation and reason.

An example of a conversation in the laboratory will illustrate the method of treatment. A student has just completed the simple experiment of heating of mercuric oxide, and his notebook shows that he has noted the change in color of the material, the deposition of metallic mercury on the side of the tube, the escape of oxygen, and the reversal of the reaction as the residue cools. He has answered all questions concisely, and the equation for the reaction is written in the most approved form—in short, a perfect record. What possible need is there for questioning the student further, or suspecting that he has not obtained the maximum good from this simple experiment? The teacher approaches and asks as he examines the written record[2]:

Q. "Why did the mercuric oxide change color when you heated it?"
A. "The chemical change produced the change of color."
Q. "What was the chemical change?"
A. "The decomposition of mercuric oxide, giving mercury and oxygen."
Q. "Which of these two products caused the dark color?"
A. "Well, it must have been the mercury."
Q. "Why?"
A. "Because oxygen is a colorless gas and it could not produce a dark colored powder."
Q. "Then the dark colored powder in the bottom of the tube was mercury?"
A. "It must have been."
Q. "What is this deposit on the side of the tube?"
A. "Mercury."
Q. "How can that be when its appearance is so different from the dark powder in the bottom of the tube, which you just told me was mercury?"
A. "I don't know, but I am sure this is mercury on the side of the tube."
Q. "Why?"

[2]This supposed conversation is based on actual experiences with students in the laboratory

A. "Because it is bright and shiny, and collects in little drops."
Q. "Did the mercuric oxide change color suddenly?"
A. "No, the red color grew darker gradually, becoming chocolate colored, and finally black."
Q. "What caused the chocolate color?"
A. "I don't know."
Q. "Is it possible that mercuric oxide is red when cold and black when hot?"
A. "I suppose it might be."
Q. "If that is true, what caused the dark color?"
A. "The fact that it was getting hot."
Q. "Then did the chemical change produce the change in color?"
A. "I thought it did.
Q. "Is it possible that the change in color is due both to the change in temperature and to a partial decomposition?"
A. "It might be."
Q. "What is the color of mercury vapor?"
A. "I don't know."
Q. "How did the mercury get up here when it condensed on the side of the tube?"
A. "I don't know."
Q. "Did you see any mercury particles jump up and cling there?"
A. "No."
Q. "Well, how did the mercury get up there?"
A. "I suppose it was like frost collecting on the window pane."
Q. "You mean that mercury had assumed the vapor form?"
A. "Yes."
Q. "What is the color of mercury vapor?"
A. "I don't know."
Q. "Did you see any colored gas in the tube as you were heating it?"
A. "No."
Q. "What is the color of mercury vapor then?"
A. "I don't believe it has any color."
Q. "You mean that mercury vapor is colorless?"
A. "Yes."

This process of questioning might be extended to include such topics as the following: Could the blackening of the mercuric oxide be caused by the presence of impurities, such as carbon? How would you distinguish between such a mixture and pure HgO? Which requires the higher temperature, the formation of HgO from mercury and oxygen, or the decomposition of this compound? Are mercury and oxygen elements or compounds? How would you proceed to prove experimentally that mercury is not a compound? Why does the test tube melt sometimes while HgO is being heated? Why does the black residue turn red so quickly when this happens?

Many other questions will suggest themselves to the skilful teacher, all of which bring out some simple fact which in itself may be worth very little, but the process is worth everything to the student. For in this way he is taught to see that even the simplest experiment is brim full of interesting deductions, but above all he is taught the necessity of close observation and careful thought.

It would not be feasible for a teacher to ask each pupil of his class all the questions upon any one experiment. Time would not permit such a process, and the fact that the conversation between teacher and student is overheard by those near by makes it necessary to vary the questions from pupil to pupil. The skilful teacher will readily learn to select questions suited to the interest, keenness, and intelligence of each pupil. Such a process requires ingenuity, skill, patience, and persistence on the part of the teacher, but the results are well worth while.

The advantages obtainable by such a method are many. 1. It stimulates interest in the work, cultivates the powers of observation, is conducive to thoroughness, and above all it develops a student's ability to think. One of the gratifying results of this procedure is the rapid development of the powers of thought and reasoning, so that the questioning process can soon become much more brief and concise. 2. It detects errors, misconceptions, faulty English, and poor expressions soon after they are set down, and at a time when the experiment is fresh in mind, so that errors are most easily and most effectively corrected. 3. The weary hours of "correcting" notebooks, the bane of the life of every teacher of a laboratory course, are almost entirely eliminated since the inspection given in the laboratory ought to be sufficient. The corrections made in the presence of the student are most effectively made because the teacher can insist that the pupil must understand every point. 4. This process of varied questioning reacts upon the teacher and makes it certain that he, too, may learn something from the experiment and thereby avoid falling into any stereotyped treatment of the course.

The successful operation of this plan of treatment not only involves the centering of effort on one pupil at a time, but the teacher must not become so engrossed with the one that he forgets the many for one moment. He must develop the ability to read from the notebook, ask questions, and at the same time keep watch of the other members of the class. This is a tiring undertaking, and at the end of a two-hour period the teacher is tired both mentally and physically. But no matter how strenuous the work becomes, the best tonic for a teacher is the knowledge of a task well done. The results of this treatment are so satisfying that I have never yet known a teacher to give it anywhere near a reasonable trial without becoming an enthusiastic follower of the plan.

In order to carry out successfully such a plan as this, certain conditions should so far as possible be insisted upon. First, the habit which was formerly general and still persists in some quarters of regarding two hours of the teacher's time in the laboratory as equivalent to one recitation hour is pernicious. If laboratory time is properly spent the teacher will teach as much chemistry in one hour as he can in the same time in the classroom; one hour in the laboratory is as great a drain upon energy and mental force as an hour in recitation; and laboratory instruction is fully as tiring as quiz work. So in self-defense the science teacher should insist that each hour in the laboratory should count as heavily on the schedule as an hour of instruction spent elsewhere.

In the second place, this plan does not permit large classes. A teacher can instruct from fifteen to eighteen by this method satisfactorily, but larger units begin to cause trouble. Under ordinary circumstances we consider twenty-two the maximum, but under war conditions we have been compelled to put twenty-five to twenty-seven in a few sections. Where this is necessary the pupils must be taught to depend more completely upon their own resources. But large sections rarely give good results in laboratory work under any conditions.

One of America's most successful teachers of chemistry says, regarding our laboratory instruction, that "while a large amount of chemistry may be learned, the object is not to teach chemistry, but to teach the pupils how to learn—to confer ability and not knowledge." I am afraid that we boast more frequently about how many pages we can cover than we do concerning the thoroughness of our treatment and the amount of ability we develop in our students. A little work well done is worth vastly more than a glance at many topics, and to my mind whatever practice we follow in the laboratory we will succeed splendidly if we keep in mind the maxim that "each chemical experiment is a question put to nature, and forethought and care are necessary in putting the question, and study and reflection in interpreting the answer."

MINERAL NUTRITION IN PLANTS—SOME SUGGESTIONS ON TEACHING THE SUBJECT TO HIGH SCHOOL STUDENTS OF BIOLOGY.

By Aleita Hopping,

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In the high school course in biology, the importance of the mineral nutrition of plants is recognized, and the subject is given a proportionate place in the curriculum. The necessity of nitrates for plant growth is emphasized. Nitrates are soluble in water and are washed out of the soil by the rain. In farming they must be artificially replaced by the addition of nitrate fertilizers. Owing to the complexity of the subject, the method used in teaching it, unfortunately, is necessarily didactic, and it is with an effort to use the experimental method that the present article deals.

In the investigation of salt nutritional requirements, selected plants are grown in nutrient solutions and the resulting growth studied. The standard solution employed in classroom demonstrations is that of Knop[1], where the formula is as follows: 0.1 per cent $Ca(NO_3)_2$, 0.025 per cent KNO_3, 0.025 per cent KH_2PO_4, 0.025 per cent $MgSO_4$, and a trace of $FePO_4$. In elementary classes, work with culture solutions is usually omitted, since time is short and the subject complex for young minds.

There has recently appeared in the literature on mineral requirements of plants, studies on the growth of buckwheat seedlings in a three-salt solution, consisting of calcium nitrate ($Ca(NO_3)_2$), magnesium sulphate ($MgSO_4$) and mono-potassium phosphate (KH_2PO_4)[2]. These salts may be interchanged, substituting KNO_3 for $Ca(NO_3)_2$, and $Ca(H_2PO_4)_2$ for KH_2PO_4.[3] A trace of ferric phosphate is added to each of these mentioned nutrient solutions. The seedlings grown in these solutions develop and mature, producing viable seeds, the plants being in every respect normal and healthy, if the proper concentration and proportions of salts are used. The essential elements that usually are derived from the soil are Ca, K, Mg, N, S, and P, and these are all contained in the three-salt solution.

The three-salt solution is simple enough to warrant its use for demonstration purposes in classroom teaching. It is essential,

[1]Knop, W., "Quantitative Untersuchungen uber den Ernahungsprocess der Pflanze," *Landw. Versuchsst*, 7:93-107, 1865.

[2]Shive, J. W., A Study of Physiological Balance in Nutrient Media, *Physiol. Res.*, 1:327-397, 1915. A preliminary announcement appeared as: A Three-salt Nutrient Solution for Plants," *Amer. Jour. Bot.*, 5:337-346, July, 1918.

[3]Livingston, B. E., and Tottingham, W. E., A New Three-salt Solution for Plant Cultures, *Am. Jour. Bot.*, 5:337-346, July, 1918.

however, in making up the solutions, that the proper concentration and the proper proportions of the salts be employed.

The solution producing the best growth when wheat plants are used, has a total gram molecular concentration of 0.0364. The partial concentration for the three salts, in gram molecules, is as follows: KNO_3, 0.0288; $Ca(H_2PO_4)_2$, 0.0026 and $MgSO_4$, 0.0050. The osmotic pressure of this solution is equivalent to 1.75 atmospheres.

It is necessary to keep the partial pressures of the dissolved salts so arranged that the total concentration shall always give a pressure of 1.75 atmospheres, since any change in the osmotic pressure of the surrounding solutions has a decided effect upon the growth of the plants.

To suggest the importance of each salt in classroom work it is advisable to make up one perfect solution and three other solutions, each lacking one of the salts. The total concentration should remain the same. The numbers representing the concentrations of these solutions are shown below:

These numbers give the partial volume-molecular concentrations of each salt and the total osmotic value is about 1.75 atmospheres in each case. The cultures should be subjected to as nearly similar environmental conditions as is possible in a changing classroom. If the jars are sufficiently large, the solutions need not be changed, and the plants can be allowed to grow in the classroom for a number of weeks.

Salts	Perfect	$-MgSO_4$	$-Ca(H_2PO_4)_2$	$-KNO_3$
$MgSO_4$	0.0050	....	0.0063	0.0194
$Ca(H_2PO_4)_2$	0.0026	0.0051	....	0.0170
KNO_3	0.0288	0.0313	0.0301	....

If it is objected that even a *three*-salt solution is difficult for high school students, the argument may be met by saying that, after all, we *do* teach mineral nutrition of plants. It is generally admitted that wherever topics are taught experimentally, the pupils understand and remember better. So if we can teach the subject by experiments, we are so much the better off. Also,

the work can readily be related to other parts of the course of study. Thus, when elements and compounds are studied, the three salts can be innocently introduced as a simple exercise of naming the elements in, and determining the composition of compounds. When the composition of protoplasm is studied, the source of the elements N, S, Ph, Mg, and Ca can be traced to these salts, absorbed by roots.

Various pedagogical devices to draw the subject close to the interest and experience of the boy can be resorted to. Thus, one member of the class can be appointed to get the salts from a drug-store. Another can get the wheat seeds from a seed store—provided, of course, that the school is not blessed with a well-stored stockroom. Another can print in large letters the names of the salts and these can be placed on the culture jars.

When the food-producing power of the world is under such universal discussion, and our dependence upon plants for our food so plain, the subject of the nutrition of the plant ought to meet with real and intelligent interest.

THE PSYCHOLOGICAL AND PEDAGOGICAL BASIS OF GENERAL SCIENCE.[1]

By Dr. Daniel R. Hodgdon,
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Ever since the dawn of history there have been fads and styles in everything. Education has had its share. There have been certain types of education which have been only fads, perpetrated upon suffering humanity because they were longing for a solution to the educational problems. There have been certain types of education which have been stylish, and to this might be added tradition, which has been a great drawback to progress in education. The subject of general science came into existence a good many years ago, so far back that no definite record is known. It met with a certain amount of response in the form of natural philosophy a few generations ago, then slowly died out as college influences worked their way into the secondary educational institution. College professors dictated what these courses should be, regardless of the welfare of the community or of the pupil. The psychology of the secondary pupil was not then well known, and I mean by that, the psychology of interest, appreciation, and selectiveness, a thing which will be discussed a little later.

It has often been asked why there has been such a difference between the graded school and the high school. At no time in a pupil's life is there such a radical change as that which takes place from the graded school to the high school. One school dominated by trained teachers, equipped in every way with the theory of pedagogy and an understanding of the psychology of young people, and the other dominated by teachers who have worked under college professors, lacking in the theory of pedagogy and totally misunderstanding the psychology of the young pupil. In the graded school more individuality is shown, and better response on the part of the pupil is given, because the teacher has the interest of the child at heart and not the interest of any individual subject. This is the age of children. The child is studied and better understood today than at any time in the history of education.

Our textbooks are improving slowly. Have you ever written something which a child would enjoy reading? Have you ever published a textbook which a boy or girl would pick up and study

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1Read before the General Science Section of the C. A. S. & M. T. at the University of Chicago, November 29, 1918.

for mere pleasure? And yet those are the problems which are confronting the school interests today. Not only are the majority of textbooks vitally inadequate and unsuitable to the student, but they are written in an abstract way and are studied only for the sake of passing certain examinations. The usual standard maintained is merely that of passing an examination. The vital subjects of interest, appreciation, and selectiveness are almost, if not totally, neglected in the average textbook of today. It is not the matter with which the child comes in contact that the text writer interests himself, it is merely a certain line of reasoning and a certain amount of information he thinks a child ought to know. You hardly ever attend a meeting but what you hear that trite, worn-out, threadbare statement, "What a child ought to know." It is not a question of what a child ought to know, but what a child can learn that will be useful to him, now, during the present day, this week, not what he ought to know for the future, but the things which are necessary for him to know to solve the problems he meets before he goes to sleep today, and that is exactly what you and I do when we do anything after we are grown up. The high school curriculum has been dominated and the teachers have been bullied into the idea that they must teach certain formulas and certain facts regardless of the interests of the school, the pupil, or the community, to satisfy a supreme dogmatic demand of the college professor. He has sent many of his pupils into the schools to teach, and they teach under his philosophy, and they will continue to do so until educational interests demand that the welfare of the school, the student, and the community be placed before the college entrance examination. Why is it one teacher is liked by the pupils? Why is it that certain pupils enjoy the subject taught by the one teacher in the school, while another may be teaching the same subject and all the pupils under him dislike, not only the subject, but the teacher? Is it the personality alone that is counting? I say "No." It is the presentation of the subject matter. One teacher is presenting it from a vital standpoint to the students, the other is teaching it merely for the subject and the subject matter, and there is a wide difference in such teachers. I would not have one of the latter in my school if I could help myself. In the grades the teacher has the interest and the training of the child at heart, in the high school the majority of teachers have the subject matter at heart.

The subject of general science again became foremost in the

attention of educators a few years ago. Some condemned it as a fad, others subjected it to the criticism of being stylish, while others believed it to be merely a subject for preparing students to take up the more serious study of science. As time went by and teachers became more acquainted with the field of general science, the more they were convinced that it was a subject necessary for vitalizing, socializing, and visualizing the everyday experiences of our boys' and girls' lives. The revival of general science is an outgrowth of a general rebellion against formular physics, chemistry, etc.

I once heard a prominent scientist say, "I well remember my own first experience in a laboratory. I had heard a good course of lectures on the subject, and was looking forward with eagerness to the laboratory work. When I entered the laboratory, the instructor handed me a pin and told me to determine whether the cross section of the pin was true or not. When I asked him what use there was in doing that, he explained that the scientist was much more interested in the minutest irregularities which he could by hook or crook discover, than he was in the operation of the machinist, whose function was solely to make machines that would go and do things. It took me about five minutes to satisfy myself that the pin was round, so round that its usefulness as a pin could not be discounted. The rest of this period was spent in trying to bend the pin with the help of the calipers into a shape that it would stand on the table point up. While the student nearest me was away, I surreptitiously placed it on the seat of the stool next to mine, and thus tested its efficiency as a pin, when the young fellow came back and sat on it. The boy is full of energy and curiosity which can only be utilized by appealing to his curiosity, which in turn reacts upon his motor activity, producing results which are not only comprehensive to the boy, but succeeds in holding his interest as well as awakening a spirit of work which it is a pleasure for the boy to accomplish. I do not, however, wish to imply that any course or study should appeal to any boy because it is soft and easy-going, nor should a course be made uninteresting and hard, to make the boy work. The only object is to get his interest and to hold it in order to obtain definite results, which will be either interesting or useful to him. That is exactly why the most of us do anything original or vital. We expect results. The usual expectation from the student of science is that he asks and receives a good mark, or gets his notebook O. K., or receives a blue check on an experiment.

As the world is full of vital, useful, and interesting things, all science may be made vital, useful, and interesting. Any one thing in science may out of necessity be all three. There are some things which are vital. There are some things which it is necessary to know, and there are some things which it is interesting to know. Now, in our life, in a day's time, we do things out of necessity. We do certain things because they are vital, and we enjoy some things because they are interesting, and we learn other things because they are useful. Upon these three great issues one directs most of his energy. With the world in which we live full of vital, useful, and interesting things, it is a surprising and sad thing that many of the people, and especially teachers, go through this world and die without seeing the beautiful and interesting things we find about us. It takes very little effort on the part of any teacher to open the eyes of his pupils to the things which will function throughout the pupil's entire life. How often have I heard an old person say, "When I was a boy we had a book, *Natural Philosophy*. This book was a storehouse of information. It was an introduction to the science of interesting, everyday things. As a result of the study or reading this book, may of us began to understand the world about us. In the years as I grew older, I always regarded that *Natural Philosophy* as most valuable." A distinguished physicist of an American university has said that such books did more to interest the people in the world about them than any subsequent books. A surprising fact, and one which is lamentable, is that too many of us as teachers of scientific subjects go through the world with a pair of scientific spectacles which have been stained the color of abstract facts, in order to filter out the rays of the beautiful, interesting, and vital science facts of the world that surrounds us.

Now with these two points in mind, that the student is interested in the subject of science, and that the world is full of interesting subjects, let us analyze them in a common sense way and see what they mean. First, I have said all boys and girls are willing to become interested in science, if they find something interesting and worth while. The world is full of interesting and worth-while things. Let us see if there is a way to bring them together.

Teachers are too likely to use a strictly scientific language, which is too scientific and too indefinite for the boy or girl to understand. Many an amusing incident happens which shows that

a student does not understand. In a test that I made recently before a class for my own satisfaction, I found a lack of ability to tell exactly what was meant when students tried to express themselves in some scientific terms. Three questions were asked: What is a molecule? What does it look like? Have you seen one? The class consisted of over two hundred pupils who were entering a normal school. They were all graduates of a high school and entered with physics and chemistry as a prerequisite. In most cases the answers were interesting. A number explained a molecule as a small round thing in things. Undoubtedly this answer would have surprised the teachers who taught those pupils the meaning of molecules. One young lady insisted that she had seen one. Several said that their teachers had seen them. Many teachers would be astounded or mortified at the answers if they were to ask their pupils practical questions on this subject.

Not along ago I asked some pupils who had gone down in an elevator, what caused the funny feeling in their stomachs when the elevator dropped suddenly, and they looked at me with peculiar expressions in their eyes, because I had asked such a question, and one laughingly said, "I don't know." I then said, "Have you ever studied physics?" "Yes, last year." "Can you not apply some principle of physics to this thing?" He said, "I have not thought of it before." And truly he had not.

One day while walking on the sidewalk a girl stubbed her toe. She ran a few steps to recover her balance, turned around and smiled. She happened to be a pupil in the school where I was teaching. I asked her if she knew why she ran when she stubbed her toe. She laughed and said, "So I wouldn't fall down." I replied, "To be sure, but why would you have fallen down if you had not run a few steps?" She said, "I don't know." A few days later she came to my classroom and said, "I have an answer to your question." I had forgotten the incident, so she reminded me of it, and this was the way she explained it. "When I stubbed my toe, my feet stopped, my head kept on going, therefore, I had to run to catch up with my head." Exactly, so she had explained it in a common sense way.

Recently on a teacher's examination paper the question was asked, "How is coal made to leave a shovel when trying to throw it on a fire?" The young lady taking this examination had done very well on her abstract questions, which dealt with the physics,

but this is the way she answered the question regarding the coal. "After getting the coal on the shovel you hold it at the furnace door, the flames jump up and lick it in." I have given you these examples all from experience, and may I say that the pupils in all cases did know what inertia was, but it would have been hard work to have associated inertia with something that had actually happened in their everyday experiences.

Examine teachers who have had physics, chemistry, biology, or any other science in school, who are not teachers of these subjects, and ask them a few simple questions about simple phenomena and they will be unable to explain. They have had physics. "Oh, yes. When I was in college, or when I was in high school, but I have forgotten it all." You might say the same of Latin We had that in college and high school, but that is a dead language. It no longer lives among us. Ninety-nine per cent of the problems of our lives are surrounded by science activities, and they are not abstract problems either. The trouble is that some of us as teachers are dead. We died long ago. We have been buried under six feet of abstract facts and formulas. We had a funeral service on notebook computations, etc. The flowers and the beauty of real living things were not present, and we have stayed dead, and nothing will resurrect us until we have thrown aside all of this material which is good-for-nothing, useless material to the average pupil, and reorganize it around the beautiful, the living, and the active world. And that notebook, the marvel of all wonders, with the objects, apparatus, and the observations; what you have seen; what you ought to have seen; what you did see; what your teacher wanted you to see; and usually a scene after school, the latter, if you are not a good mind reader and have not clearly read the mind of the teacher, and were not able to find out just what was expected of you. Some one will say, "You are not a science teacher." Then I thank God I am not, and I don't want to be, if science cannot consist of the real, live material and the problems which you have at hand to be solved from day to day. In other words, we must talk to pupils, we must teach pupils, and we must learn with pupils in the language they know, and in the environment they understand.

There is another valuable psychological reaction which has been talked about a great deal but has never been practiced, and that is to make pupils observe. Ninety-nine per cent of the science teachers do not teach pupils to see things, and it is only

one teacher out of a hundred we find acting upon the principles of psychology to produce observation.

It has long been a practice of mine in the classroom to spend ten minutes of the period in answering questions or discussing observations of the pupil. These ten minutes I presume have been most interesting. I have allowed each pupil to ask one question, or to give one observation. Throughout the year I kept account of the questions asked by pupils about things which they had seen. The number amounted to 1,056. In succeeding years I tried to keep account of the number of times the same question was asked by different pupils. Sometimes it was as many as ten, and other times it amounted to many more. This shows that pupils see the same interesting things, from day to day. The teacher should be willing to spend a little time in trying to open the eyes of his students to the art of observing things. Such an incident as this has been reported. One girl said, "Last night while washing dishes, one glass stuck tightly into the other, and I was unable to remove it, until I had placed the glasses in hot water. I asked my mother why this was so. She did not know. She had not thought of it."

Another incident by another pupil. "In our room we have a fireplace. Last night we put some wood on the fire, and a short time afterwards a piece of the wood had blown almost into the middle of the room. I tried to explain it, but I could not find any reason." This question was answered by one of the other members of the class. Such questions as these are coming up daily in the experience of everyone.

As soon as pupils begin to realize that they can see and understand some of the things about them, they begin to react. A short time ago one of my pupils coming across the meadows observed the fact that the fog stood about three feet above land. She wanted to know why. She had crossed the meadow hundreds of times before entering the science class, and never wondered at this phenomenon.

Another asked why ice steams on a hot day. I was rather amused with the answer given by one of the pupils who had had considerable science. He said, "Because the ice was evaporating and you could see it go."

Truly we can teach vital problems in a vital way. We can also teach the students to observe if we only get away from the habit of trying to drill a few definite laws into their minds to be remembered long enough to take an examination and to create

within them a natural dislike for the world's scientific facts. You should not be surprised to find the boy in a physical laboratory reading *Popular Science Monthly* instead of doing a useless experiment.

I once knew of a teacher who had given an experiment to a boy to do with a motor. He had careful instructions laid before him and he was supposed to follow them. About one-half of the period gone, the teacher stopped at his desk to see what he had done. He found the boy had not written anything about the motor, but was busily engaged, and the teacher rather sharply remarked, "Why have you not started your experiment?" The boy jumped because he had been absorbed in examining the motor, and said, "I have found out how the thing goes one way, but I cannot find out how it goes the other way." If the teacher had had a sense of humor and had understood the psychology of a boy, he would have said, "Keep at it until you do find out," but instead he dismissed the boy from the class and gave the remaining number of the class a lecture on following instructions. "Never mind what you want to know, just do as I tell you. You will learn something that way. If you want to find out anything else, do not find it out here." Rather poor psychology, and I doubt whether any pupil in that class will remember that teacher as being one which influenced his life.

Students can easily be taught to observe and become interested in anything if they are allowed to discuss things about them. How often have I heard a pupil say, "I have seen more things this year, going to and from school, than I have ever seen in my life before. I notice the clouds every morning, I have tried to predict the weather. I notice the people in the car. New things, new experiences happen to me, and I try to explain them." This is the spirit of observation. Not only have I had pupils come to me during class hours, but often have students come after school to ask a question which they could not answer about some phenomenon they had seen. Why? Because they are interested, and because science is a thing which produces the spirit of investigation, even on the dullest mind. Pupils have written letters after graduation asking for explanation of certain things which they have seen. They will never lose their interest in science.

The chief reason to my mind for the study of any general science in school is to give a consumer knowledge. We are all consumers, as well as producers, but as a consumer we must know something about food, its value in a human body, food

which is costly, as far as food values are concerned, and foods which are cheap, but useful. Every man should have some knowledge about his clothing; he should be able to be a judge and be a fair judge, not an expert, when he is buying a piece of clothing, to know whether he is getting the best value. He should have an intellectual viewpoint regarding his home, ventilation, the building material, the heating system, the water supply, etc. He need not be an expert, but a little knowledge will give him an opportunity to have an insight into economical values and give him a basis for forming good judgments. If he travels he should have some knowledge regarding the best methods in traveling, safety first, and general conditions which will keep him healthy and strong. His medicine is a vital problem when he is ill, or has sickness in his home. He should be well aware as to what are the ordinary advertisements which claim to effect many cures and produce none. He should have an intelligent viewpoint when a physician enters his home, and enough scientific knowledge to carry out and understand the reason for the directions which a doctor may give. All such material is included in the practical science of everyday life.

The subject matter of general science has been a field for investigation and thought. It has been exploited; the child has been exploited; and the teachers have been exploited. I have definitely made up my mind that in general science, physics should not be taught as physics, chemistry as chemistry, biology as biology, and astronomy as astronomy. Some of us have tried to make general science a sort of biology; others, elementary physics; a few have stuck to chemistry; others have emphasized astronomy; still others agriculture; but science must be divided into two classes, *pure* and *applied* science. In the pure science we have physics, chemistry, biology, and astronomy, etc. In applied science we have agriculture and physiology. These two subjects are taught in a practical and sensible way, and they do not need to be retaught in part in general science, but out of the pure science should be selected such material as can be applied to the everyday life. There are certain applications of physics, chemistry, biology, and astronomy which are interesting, helpful, and useful in everyday life. Some have tried to crowd in agriculture on top of this, and have made a botch of the whole thing without recognizing the fact that agriculture was a practical subject to start with, and always will be taught in our school as a practical subject. What students need to know is more of the

everyday environment of science which they would not get from the formal study of the pure science.

There are many who would say that what we propose is hard to teach. Just so. It does take time, thought, study, and an abundance of energy because you must be a real live wire. No semi-dead teacher has any chance in a classroom full of live, hungry, and willing learners.

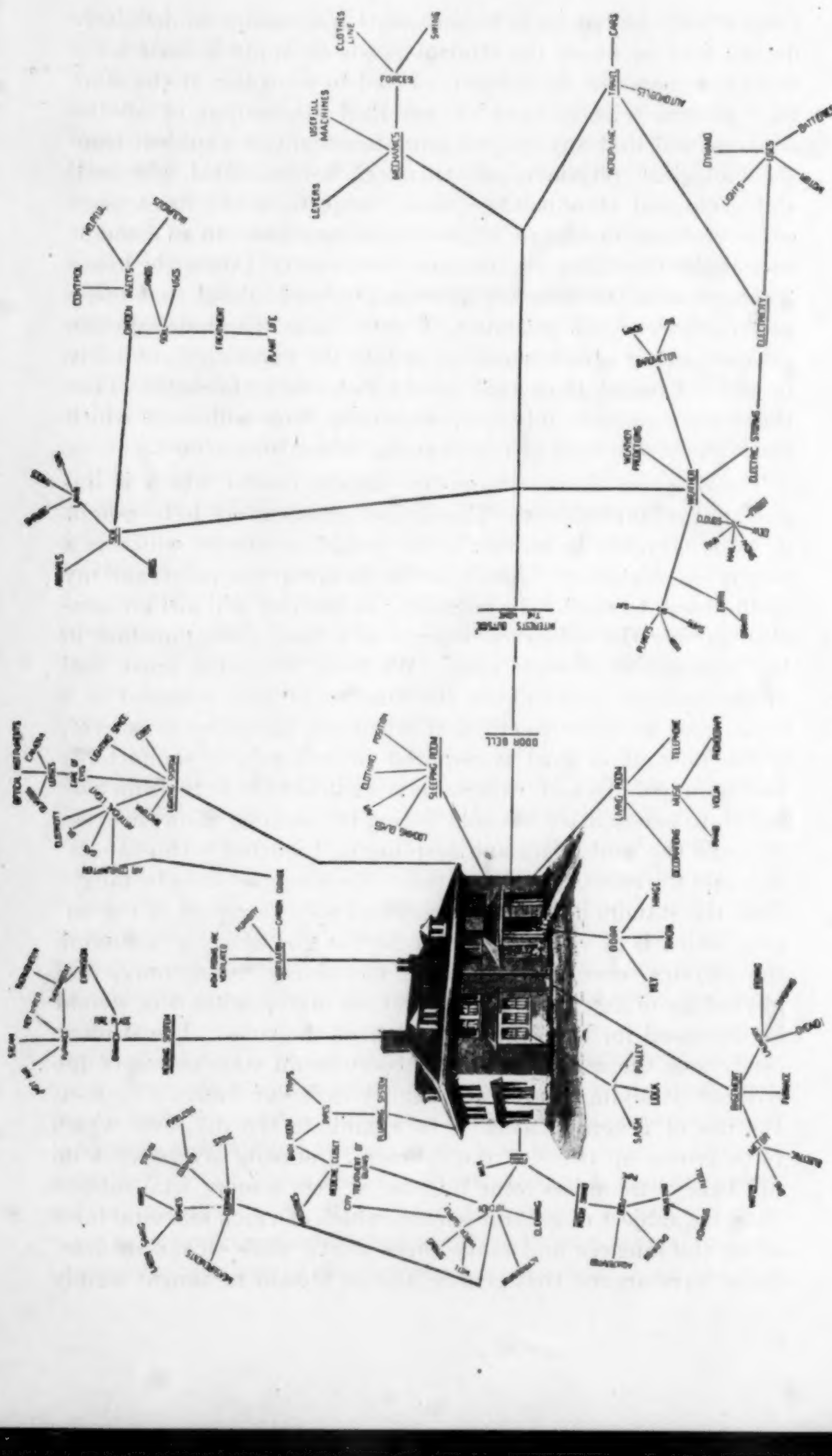
What to teach becomes a problem. One thing is certain. Definitions and dry scientific facts are not to be taught first without any foundation. An example of this is found in a science class when an instructor attempts to teach inertia. The definition for inertia is, "Every body continues in its state of rest or of uniform motion in a straight line, unless compelled by some external force to change that state." The student is lost before he gets through the definition. It means little to him. He sees no relation between this and his own environment, and to tell the truth he has learned little. Suppose he had been asked why one must be careful to wait until the car stops before getting off? This is something he knows about. Why should one get off always facing the direction the car is going? Suppose the teacher arranged chairs in the classroom and had a demonstration of mounting and dismounting a car with books in one hand. What is the result? Everyone is ready to take part. Some one shows how one should get off the car. Another immediately says that is wrong. Why? If the car is moving and you get off with your back in the direction the car is going, what happens? Why? What happens when a car starts and you are standing in it? Why? We have got to call this something. What? Inertia. What does inertia make you do? What does it make everything do? What is inertia? What way does it make things go if they are moving? Tell all about inertia, etc. Hundreds of examples can be given, from the spilling of soup by pushing the plate, to why the world keeps on turning.

If I should ask any one of you to tell me how the water runs out of a washbowl, what would you say? Does it run from right to left, or left to right? Does it always run in the same direction? Why does it assume a turning motion as it runs out? Do you know? Why don't you know? The phenomenon happens every day of your life.

An organization of the subject matter for the general science I found to be a very difficult thing, and the more I studied the

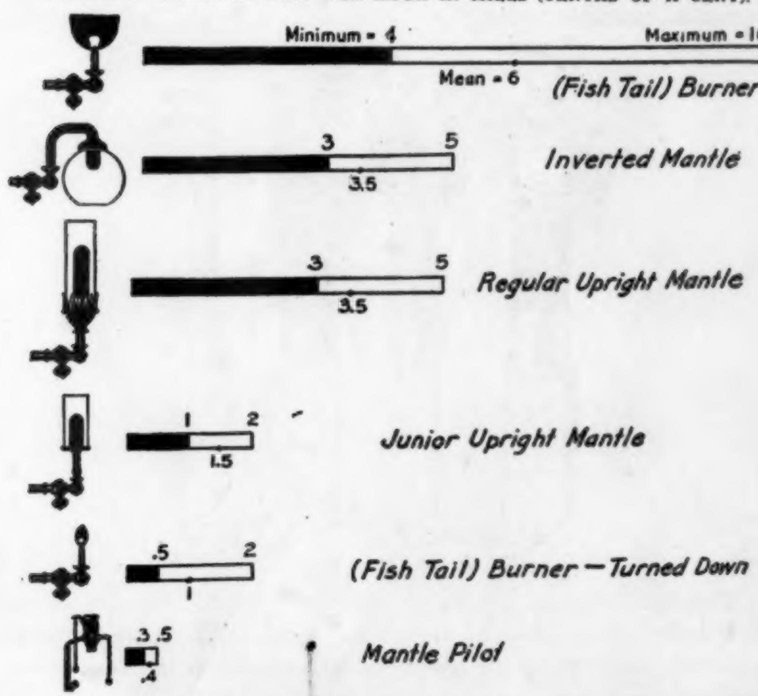
proposition, the harder it became, as I was unable to definitely fix the field in which the student needs to apply himself for a thorough course in the subject. I had to recognize at the start that general science meant a practical application of all the sciences, and that any subject must be taught as a subject from the biological, physiological, chemical, astronomical, physical, and geological standpoints. Some subjects would have more of the divisions in science, others would have less. In an attempt to organize this thing around some vital center, I drew the house represented in the diagram on page 316, and about that home as the center of all activities, I drew lines to designate the subject matter which would come into the experiences of a boy or girl. I found that this would not cover the field. That there were outside interests, especially those interests which function in the lives of pupils going to and from school.

The diagram simply shows the subject matter which is important for him to know. The subject matter is not to be taught as pure scientific facts, but to be taught as science which is a part of his existence. There must be some starting point, and my method was to start with humidity, as the boy and girl are usually starting the subject of science at a time when moisture in the atmosphere is very vital. We have learned a great deal in the last few years about the amount of heat required in a home, and we have found that when the humidity is correct, a less amount of coal is required to maintain a comfortably heated home. In fact, experts have estimated it to be from one-eighth to one-quarter less coal during the season. Now, in order to make the work plain and systematic, I started with evaporation and the effects of evaporation. Each subject is to be taught from the standpoint of all science, and only that part of the science which is of vital use for the boy or girl to know, therefore the physics, chemistry, biology, metallurgy, astronomy, and physiology of any particular subject, no matter what it is, should be discussed for the subject in view at the time. The student easily sees the relation of the subject to all standpoints of life without studying the subject under different heads. In fact, the use of general science is to annihilate the divisions which have grown up between the different groups of sciences. I do not believe there has come into our system a more vital subject than the subject of general science, which can pick out vital facts of all the sciences and make them worth while to the student. Some have argued that general science should be taught simply


DOOR BELL
INTERESTS OUTSIDE THE HOME
MECHANICS
FORCES
LEVERS
USEFUL MACHINES
CLOTHES LINE
SPRING
TRAINS
CARS
AUTOMOBILES
AEROPLANE
ELECTRICITY
DYNAMO
CELLS
BATTERIES
LIGHTS
WEATHER
BAROMETER
WEATHER PREDICTIONS
ELECTRIC STORMS
CLOUDS
PLANT LIFE
SLEEPING ROOM
CLOTHING
POSITION
LOOKING GLASS
LIVING ROOM
TELEPHONE
PHONOGRAPH
MUSIC
VIOLIN
PIANO
DOOR
HINGE
KNOB
KEY
SASH
PULLEY
LOCK
BASEMENT
FURNACE
LAUNDRY
PLUMBING SYSTEM
HEATING SYSTEM
FIRE PLACE
OPTICAL INSTRUMENTS
CAMERA
LENSES

to prepare students to take up the serious study of other subjects in science, but general science is a serious study of itself. It may or may not prepare students for future study in a more scientific manner. It is bound, however, to assist the boy in any future subject of science, even though the ultimate aim is only to give him a better understanding of his environment, and that, after all is the ultimate aim of the teaching of general science. Natur-

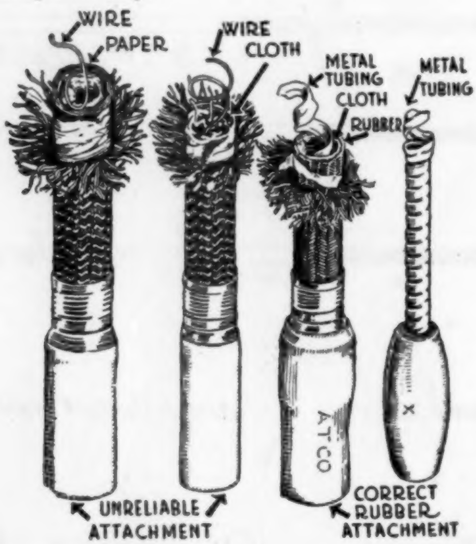
NUMERALS REFER TO COST PER HOUR IN MILLS (TENTHS OF A CENT).



—*Cost of gas used per hour in some common gas appliances*

ally, as soon as we start any subject, there must be an organization or plan in which one factor fits into another, and that plan seems to start with the moisture getting into the atmosphere, effects of the moisture in the atmosphere, and the moisture coming out of the atmosphere, and under those three groups we would naturally have humidity, the effects of humidity, evaporation, and the effects of evaporation, and this takes us into discussion of the use of many things about the home. It takes us into physiology. It discusses the humidity of house sleeping rooms. It takes us into the pantry, where the butter is kept. It takes us to the shore, where we go in bathing. It takes us to

the sickroom. It tells about the iceless refrigerator, therefore the subject can only be taught from all the standpoints of science. When the discussion leads to moisture coming out of the atmosphere, we learn about weather, weather predictions, clouds, and other things related to the subject of weather. This leads us to the study of barometer, wind, air pressure, and finally to ventilation. Under the pressure of air many examples may be found as practical applications, non-skid tires being a very common example today.



Thus it is easy to see the lesson may have the physics, chemistry, physiology, etc., of the topic, combined in an understandable way as a whole, without the student realizing that many divisions of science have entered into the work.

Air pressure leads us to discuss boiling point. The subject of heat follows. How our homes are heated. Uses of heat, cooking utensils, saving of heat. Study of our heating systems. Lessons on fuel. Value of different fuels, types of burners, wasteful and saving forms of burners. Here is an illustration showing how the Bureau of Standards at Washington has worked out the relations between fuel and different burners for lighting purposes. This is really vital, and the student knows it without being told. He sees an immediate use for the lesson. I wanted a good lesson for students who were using gas pipes at home. While we were studying the subject of using gas, there was no better plan than to make a collection of the different gas tubes. Here you see the

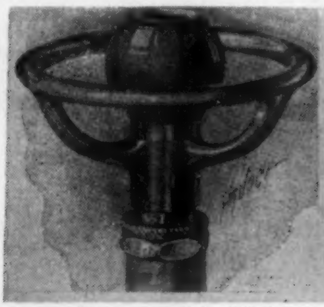
results—a real lesson in hygiene and relative values. One gas pipe is made of paper and wire, covered with cloth. It is bound to leak, but it only cost three cents a foot. There were several grades as the illustrations show, varying in price and quality, until we reach the best, which is reliable. A good rubber connection, metal tubing inside which is well covered, not only to prevent gas from leaking, but for decorative purposes. This cost fifteen cents per foot, but was well worth the difference because of the hygienic value.

An object lesson on cheap penny candy. This doll was prepared by the students of the State Normal School, Newark, N. J., from cheap, unlabeled candy obtained at the penny candy-store near the school building. Buy candy which is labeled and is free from adulteration.

Results of burning. Ventilation, results of breathing, carbon dioxide, food, medicines. We have an exhibition of 240 useless patent medicines taken from homes of students. Study of med-

icines, candies, etc. I am showing you an interesting laboratory experiment performed by my students on penny candy. The material was collected and the experiments performed because the students saw something useful and worth while in this work. They were educating themselves to become better citizens, and incidentally preparing others to become better citizens, when they dyed the clothes of this doll with candy dyes.

The study of water follows that of food. Water supply dangerous and good. Indicentally, the drinking fountain of the school building comes in for its share of criticism.



A danger always present in this type of drinking fountain is that of breaking the teeth of one child if another playfully pushes him when drinking. This type of drinking fountain may prove to be worse than the common drinking cup. Bacteria will remain in the little bowl and in the water standing in it. Even if the water is allowed to run continually, bacteria and disease germs have been found constantly moving up and down in the water.

This type of drinking fountain prevents the danger of having the teeth broken. A person drinking cannot get his mouth in contact with the metal. There is no bowl for the water to run back in, since the water meets in a spray at the center of the fountain and the excess water falls back into the drain.

I hold in my hand two types of drinking fountains, one dangerous and unhealthy. It is so constructed as to allow disease bacteria of all kinds to collect. Children break their teeth on such fountains by pushing each other. It is a bubbling fountain and may easily spread disease. Here is another type made to prevent children touching the metal and breaking their teeth. It is clean, sanitary, and wholesome.

Of course, under this subject come water pressure, and the physical and chemical lesson, as well as the lesson in hygiene. Bacteria and disease naturally follow a subject of water. Light should get its share of attention next, since light is the greatest germicide known. The vital subjects of the pupil's environment must be taught, and no general science should miss the opportunity to teach safety first.

In no part of school work is more practical psychology required than in the teaching of science. One of the chief faults of a teacher is to dominate a class, to talk too much. The ideal

place for a teacher is in an out-of-the-way place in a classroom trying to keep still. The teacher may ask, "What am I paid for?" A teacher is paid to use his brains and keep his mouth shut as much as possible. This is the hardest job a teacher can have. It was a hard lesson for me to learn, but I can conscientiously say I did pretty well after fifteen years of trying.

Enthusiasm is needed in every recitation. Pupils should fairly climb over each other to get into the science room. One day the history teacher came into my room just after the class had started, expecting to see something unusual. She said, "Will you kindly ask the class to go more quietly from my room to your room? They fairly walked on each other, and they have been doing the same thing for several days." What had happened? Why, I had tried another experiment to get enthusiasm into the work. I had decided that one member of the class should conduct the class each day, and that each one who wished should report on any observation he might have seen. In the first place I had a barometer, thermometer, and stormograph to be read and adjusted each day, weather flags to be placed on a pole, and weather charts to be read. Those who got into the room first reported on conditions.

Observations came next for ten minutes. These produced enthusiasm and many discussions. Here is where the teacher comes in. Do you know there seems to be an old feeling about teaching that we must ask a lot of questions? Is it not funny when we think of it? We are forever asking questions of others who may or may not know the answer, when we know the answer. Why ask questions when we know the answers? When we want to know things in real life we don't know, we ask questions of those who do know. What an ideal method to use in class work. Let the student ask questions of the teacher instead of the teacher asking questions. Many a time one pupil knows a whole lot about some subject. How interesting and helpful to the whole class to have that student get out in front and let the class ask questions of the student. He is always glad to tell what he knows. Here is where the case system may be used. The case system has been found valuable in teaching law and medicine. It is excellent for teaching general science. There was a time when the project method was in vogue. But no one today knows what a project is. We thought we knew once, but since that time every known idea and method under the sun has been called a project.

A boy or girl has something special to contribute. Let him do it, and let the rest of the class, together with the teacher, join in asking questions about the matter presented. The students get a sense of importance which communicates itself to other pupils, causing them to want to find something to contribute in like manner.

Why should a teacher do any of the experiments in science? Any one of his pupils will stay after school and prepare the experiment, study it, and gladly explain it to the class the next day.

The recitation usually opens by a student's voluntary recitation as to the most important part in today's lesson and why second in importance and why, etc. No one is called on. All recite because they want to. Each student rises and is recognized by the leader. Do they enjoy this recitation? They certainly do. They are not sitting in their seats waiting for the teacher to call on them. Their mind is on "What can I contribute?" Interest is often stimulated by dividing the class into two groups, and keeping account of each side. The students will see that every student contributes, and if the teacher is wise he will see that the class is held to contribute essential things. The class is a good judge of this if you allow it to use its judgment as a whole.

To sum up in a word, general science is essential to the school as a medium of teaching a student more about the environment he lives in. It is also a medium for teaching students how to express ideas, to rely upon themselves for explanations when strange phenomena appear, to see more of the world about them, and to ask questions about things. The grade pupil asks more questions about his environment than the average high school pupil of science, but you give the high school pupil the same opportunity and he will become a real live question mark.

The future of general science will be for the student and not the subject matter.

The world has advanced by finding real problems and solving them. To study means to solve vital problems. The average person does not have time to spend on anything but the real problems of his environment. General science must be, and will be, the source through which vital contact with the real things in nature are made.

NOTES ON BIOLOGY TEACHING.

By Benjamin C. Gruenberg,
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We know enough of biology to realize that no two individuals are precisely alike. But we understand enough of life to recognize that no trait or feature is unique. In offering the following notes to my fellow teachers of science, I assume that certain types of problems recur constantly under a great variety of circumstances; that certain types of errors are committed by a great variety of teachers; that certain types of situations arise in connection with a great variety of topics.

These papers are direct transcripts of the memoranda submitted to teachers in the way of criticism and suggestion, following visits to classrooms or laboratories, and they are offered in the belief that they will suggest to others the solution of problems, the avoidance of confusion, the prevention of blunders, the facilitation of procedure. These notes cover such matters as the teacher's own progress in subject matter and in teaching technic; the logic of the pupil or the teacher; details of laboratory or classroom organization and management; blunders and confusion arising from defects of language; the use of conventional or elliptical expressions that obscure or confuse thought; attempts at insight into the pupils' minds and motives; fragments of technical information. The notes extend over a period of several years, and were addressed to some twelve or fifteen different teachers.

I.

(The lesson was to show that milk consisted of several different kinds of stuff; introductory to study of elements and compounds; demonstration of qualitative analysis of milk.)

In the effort to stimulate thinking we are in danger of becoming petty or exasperating. There is the danger, too, of adopting a formula and thus defeating our own purpose. For example, we ask, "How do you know this or that?" Until it becomes a habit. You ask a pupil, "How do you know it is cream?" and the pupil answers, "Because it has less weight." The fact is, how ever, that your question has no real meaning. The pupil does not know that "it" is anything; he knows only that that particular "it" is *called* "cream." In other words, the question you ask is a purely nominal one—and besides, it is irrelevant. The point of significance was, it seems to me, not the ability to name the two layers, but the universal ability to discriminate—the *milk* had

resolved itself at last into *two kinds of stuff*, an upper layer and a lower layer, call them what you will, but certainly *different.*

Again you say, "Prove that *things with less weight* go to the top." "How do you know that those at the bottom are heavier?" "How do you know that the heavier go to the bottom?" You have cornered a girl, and have forced her to go through the motion of answering a question. In reality, however, she knows about lighter and heavier, about floating and sinking, not by comparing the rock and the cork here and now, but from hundreds of experiences dating back to her infancy. You ask the pupil to "heft" the rock and the cork and then to draw an inference that *may* be valid, but that certainly is not warranted, as a generalization, from the immediate data. Do all "light" *things* float; and do all "heavy" *things* sink?

A word about the choice of terms. We use the word "thick," which strictly speaking is a term of dimensions, while discussing relative fluidity and viscosity. In the same way we speak of "weight" as though it were synonymous with "specific gravity." If you had taken a few minutes to explain or to make conscious what most of the pupils already feel vaguely, namely, the notion of *relative* weight, or specific gravity, you might have saved considerable confusion, and all of the discussion on floating and sinking.

In using the blackboard we should be careful about the selection and the arrangement of words suggesting what we do not mean to suggest. For example, you placed on the board:

I. Cream.
   A. Thickness.
   B. Weight.
   C. Color.

II. Skim-milk.
   A. Curd.
   B. Whey.

The immediate implication of this arrangement is that you have analyzed the concept *cream* into its constituents, and the concept *skim-milk* into its constituents. But now you have "cream" made up of three *qualities* and "skim-milk" made up of two *substances.* In the one case you have analyzed into substances or components; in the other, into adjectives or characteristics.

In the effort to make a physical demonstration of every idea as we go along, we are likely to fall into absurdities, and we are likely to be wasteful both of time and of materials. A pupil says that the way to separate the liquid part of the whey from the solid part is "to put it on the filter paper." Promptly you

come back, "Oh, very well; let's try it." The absurdity lies in taking the pupil's thoughtless suggestion at its face value. Has not the whey just come through the filter? The proper response on your part would have been to make the pupil explain what he would expect the suggested procedure to accomplish; and sooner or later to make him see the superfluity of the suggestion. The amount of whey at your disposal, moreover, was so small that in your eagerness to demonstrate you threw it all on a filter too large to be even decently wetted by the liquor.

In the effort to make perfectly clear the difference between knowledge and information, we should guard against discrediting information as such. After all, we should not get very far if we all had to depend exclusively upon first-hand knowledge. A pupil reports what turns out to be not a personal experience, but mere hearsay. "A girl told me." You come back, "And you believed her?" You say it in a way that makes one feel ashamed ever to believe anything. It is, however, no fault to believe. The point should be, pretending to know of one's own knowledge instead of candidly acknowledging the source of inspiration or information.

You understand, of course, that I consider your work excellent. If it were not very good, I should have to find entirely different kinds of weaknesses to criticize.

II.

(Lesson similar to the preceding; by another teacher, one of little experience in science work.)

You have ready control of the class and of your "lesson" material. Such difficulty as you experience in presenting or "putting over" the ideas seems to me to come chiefly from lack of experience with this kind of work. As you think over the various ideas that you wish to present, and especially as you notice the kinds of misconceptions and misunderstandings the pupils manifest, the difficulties will clear away.

Some of the difficulty is of course due to the unfamiliarity of the material.

You should put the pupils to work more, instead of doing all the work yourself. For example, you said, "If I take a piece of granite," etc. Why not have the pupils take the piece of granite or marble, etc? You are asking them to recall or to imagine; this is often necessary, but in a case like this it is better to have them handle and see.

You should be prepared to have the pupils make suggestions that are different from those you are working for. For example, you were trying to get them to tell you how we know that milk is not homogeneous. The pupils spoke of changes taking place when milk is heated. All the suggestions made were sensible, although they were not the ones you were looking for; you received them if not with disapproval, at least not with cordiality.

The "marble" with which most of us are familiar is obviously made up of more than one kind of stuff—the characteristic feature is the irregular streaks of gray or brown running through the white matrix; this is a poor illustration of an apparently homogeneous substance.

There was apparent confusion between *stuff* or material and *things* or objects. "Name something that is of one kind of stuff." A pupil named the desk. What does the question mean? What does the answer mean? Again, you asked them to make a list of five *things* made up of only one material. Suppose a pupil brought in two lists like the following: A. A brick; a broomstick; a coin; a celluloid comb; a leather strap; a granite tombstone. B. A table; a shoe; a dress; a house; a picture; a book—six of each for good measure. Would you consider them acceptable, and of what use would they be?

While it is better to present a sensual demonstration in place of a memory or an image, it is not worth while to elaborate the obvious. Light things float to the top. The floating of corks and the separation of the layer of cream are sufficiently familiar to need no further demonstration. A milk bottle with its layer of cream is nice to have on hand; but in its absence, a cork on water is not of much use. Indeed, the demonstration raises too many secondary questions that can neither be lightly dismissed nor adequately disposed of in a few minutes.

Where you need a demonstration is on clearing up the difference between a mixture and a compound. Perhaps you have not used the word compound; but mixture is easy enough and must be clear as a basis for further work. For example, a mixture of oil and water, which "unmixes itself"; a mixture of grain and chaff, which can be unmixed by a current of air; a mixture of sand and sugar, which can be unmixed by dissolving out the sugar; a mixture of sand or sulphur and iron filings, which can be unmixed by means of a magnet; a mixture of oily seeds (sunflower, flax) and starchy seeds (corn, beans) which can be unmixed by flotation, and so on.

The use of precise terminology should help to clarify the thinking. For example, the word "weight" is used loosely in comparing milk and cream—relative weight, or specific gravity was meant; "thickness" as meaning the degree of fluidity or viscosity leads to loose thinking.

We must be careful in the use of the colloquial. You said, "Has any *one* a mistake on *their* paper *they* would like to ask about?" "Is this any different than . . ."

III.

(Lesson on the root.)

It is well to encourage pupils to formulate hypothetical explanations of phenomena (e.g., to explain presence of green color in the upper part of a carrot root), as you did. It is an essential part of the scientific attitude; but once we open the door to hypotheses we must do so without prejudice. Every hypothesis must be given due consideration—e. g., the strange juice in which the carrot had been kept may have produced a chemical change. You, of course, already know that this and many another of the suggestions are quite untenable; but to brush aside the untrue explanations without showing why they may not be considered is to vitiate the procedure and to reduce the situation to a contest in *correct guessing*. It is no more absurd, *a priori*, to suspect the red juice of producing a green color than it is to suspect the green grass of producing the red blood of the cow. You and I happen to know better—in this particular case—but until other people also know, we should encourage every effort to find out. The formulation of hypotheses is a valuable instrument in this direction, and should be encouraged without prejudice.

"The plant is a living thing, is it not?" The class says, "Yes," but there is not enough volume or enthusiasm to indicate conviction on the question. Your question is proper enough as a means of concentrating the attention of the class on a point from which a new departure is to be made, but unless it has actually integrated the class, you have wasted time. It is not to be expected that a class will maintain 100 per cent attention for even three minutes at a stretch; but it is certainly desirable to start each paragraph with 100 per cent attention.

"We call things that we found in the seed *food*." Did we formulate the concept *food* inductively from what we found?

I notice for the second time that the pupils on the left side of the room appear to be more neglected—some eight or nine

pupils apparently waiting. I wonder whether you are aware of the fact that you turn more to your right than to your left? Perhaps your eyes have something to do with this. At any rate, I have repeatedly noticed that many teachers do acquire the habit of dealing with a certain region of the room to the almost complete exclusion of the fringe or other corners. Please look out for this.

You miss many excellent opportunities to use the blackboard. In this particular lesson there were too many categories in hand for convenient manipulation. The danger of confusion is too great:

The plant, the root, the green parts.
Manufacturing food, storing food, taking in food.
Food, food-making materials.
Soil, minerals from the soil.

"Leaves and stems manufacture food in the carrot." Where are the stems? Very obviously the stalk-like things to which the "leaves" are attached. But these stalk-like things are not stems; they happen to be parts of the leaf. You had to come back later, after "stems" in plants had been used several times, to *illuminate*.

The "line" between the cortex and the central cylinder is the growing layer or cambium, not the f. v. bundle. There are fibers and vessels in the cortex as well as in the xylem.

"Radish leaves might be just as healthy for us as other leaves, but . . ." Just what does this mean?

Does the sugar we add to the rhubarb "destroy the acid"?

Most of the time was given to a didactic presentation interspersed with questions. The ground was well covered but not well organized. The presentation was clear but not dynamic. It seems to me that the dynamic element was repressed rather than absent. I feel that this is a part of the traditional dignity infesting our relation to pupils. You might get a great deal of satisfaction if you let yourself relax more.

The plant is of concern to the pupils, I take it, not because of its structural differentia, not because of its color combinations, not even because of its availability as food. It is significant to the pupils here and now because it is *something doing*, a locus of actions and reactions, a dynamic system in short, a system involving *processes* that are significant—diffusion and transfer, chemical transformation, transformation of sunlight, redistribution of the products of photosynthesis, as accumulated material and as growth material, immediately or presently converted

into more *live plant*. Something doing every moment and in every part—energesis, assimilation, gas exchange and so on—processes that are significant not alone in this poor groundling carrot, but processes that are of the utmost significance to us as men and women, as citizens and soldiers, as mothers and children, as producers and consumers—as civilized human beings, in short. But instead, I feel the poor children straining their memory machines in an effort to remember what was what.

There is indeed much in your lesson worth remembering; it is a picture or a schedule in two dimensions—there is length and there is breadth, but slight thickness; and time has no place in it whatever.

You are capable of thinking in at least three dimensions, and I am sure you can put the solidity of these realities more effectively before the pupils.

A SYSTEM FOR CHECKING UP INDIVIDUAL PROJECTS IN BIOLOGY.[1]

By Mrs. Nell J. Sanders,

Calumet High School, Chicago.

Some five or six years ago, I fell upon a plan for presenting subject matter in biology which not only has proved itself workable, but has led to possibilities which I have not yet wholly exhausted. It may be applicable to the physical sciences as well. With agriculture and biology, subjects closely connected with projects not immediately within laboratory walls, it is very useful. This outside work without some such plan for organizing and crediting is apt to be done in a perfunctory and unsatisfactory manner if made compulsory, or by only a small percentage of pupils if voluntary. And this outside work just now is decided ly imporant in that under its scope come projects that help in the great problem of food production, such as beekeeping, care of poultry, and garden making. More than that, projects such as these serve to relate education to life. Because of their concreteness they make an added appeal and give worth and vitalness to our school work.

It has always seemed to me that leading a pupil of high school age through the maze of plant and animal types too often considered biology is like attempting to build a camp fire with water-soaked wood. Occasionally we get a slight flicker of

[1]Read before the Biology Section of the C. A. S. & M. T., at the University of Chicago, Nov. 30, 1918.

enthusiasm and interest, but we soon extinguish the possibilities of the study of life with the great load of man-made classifications.

I have never been daring enough to organize a course in which plant and animal type study were omitted, not do I think it would be wise. We cannot afford to cast away the knowledge which has thus far been accrued in our sciences, and we ought to give some goodly share of it to our pupils. But why not make the evolution of structure a side issue (its formal study properly belongs to the morphological courses of college), and why not open up the enticing byways of our sciences?

We may not have the genius of an Agassiz nor the kindliness and humanness of a John Muir. But in spite of our personal limitations we may make our course full of interest to the pupils if we broaden it sufficiently. Our subject matter may attain a scope even greater than our own personal experiences if we cover the possibilities of our pupils in their varied home surroundings. We may thus answer the needs and interests of those who come within our sphere of influence and make our sciences dip into the home life and after-school hours.

Suppose we personally have never had charge of poultry; why shut our eyes to the zoological possibilities there? Why not give credit for that work to pupils who are helping the nation with food production, and thereby encourage other students to do likewise? White mice may be abhorrent to us, but some boys and even girls may always be found in a class who will delight in raising them for the profit there is in them, as well as for the joy of having them for pets, and there is now a Government market for them. Belgian hares and rabbits are good food and easy to raise. Their production should be encouraged. The collection of destructive insects, and of such roots as those of the vile weed burdock (which in large quantities may be disposed of to drug mills) should be credited. If a little influence is exerted every pupil in botany will make a good showing at home gardening. It is projects like those mentioned above that lend excellent material for scientific work, increase the responsibility of the pupil, and make the subject of biology worth while from the standpoint of production. This work may be considered war work in the strictest sense of the words.

My plan for presenting and checking up problem projects such as these makes possible a kind of work which before I

adopted it I found out of the question. In the classroom and laboratory a minimum amount of work based on the important elementary framework of our sciences is required of all pupils. Linked with this required course of study is a system of individual projects, in some instances closely dependent on the course, in others only vaguely suggested by it, and purely elective in character. I grade the elective projects according to the time they take and their difficulty in handling—and I give appropriate credit for each one.

In order to grade and check up the elective work I have organized the following system. Until all the projects are completed the pupils are graded not on the way they carry out their elective work, but on the required work only. Incidentally, I presume, extraordinary enthusiasm of various pupils for voluntary projects influences the summing up of ability to a certain extent, but the performance of individual project work is not graded until the last mark of the semester is given. At that time every pupil must show receipts for twenty-five units of individual work, or credit is withheld for failure to complete the course satisfactorily. If pupils voluntarily do much more than the amount of work required, the last mark is raised to show appreciation of the fact.

In this project work, each pupil exercises the right of choice and plans his projects. For reference, a list of possible and suggestive projects is placed in the pupil's hands each semester. From this list he chooses at least one major project (ten units in value), and enough other projects to make in all twenty-five units. The list is always open to suggestions and additions. The work is done during school hours, on field trips, in the laboratory under the direct supervision of the teacher, or outside of school and at home. Experiments which may be set up in the laboratory are carefully labeled for the benefit of the other students.

When a given piece of work is accepted, whether it be an experiment performed or an herbarium completed, a receipt in units is given the pupil. Toward the end of the semester these receipts are checked up for each pupil, and record is made in the class book. Checking up the work done demands frequent interviews with individual pupils concerning projects in which they are interested; nevertheless the plan saves time in other ways. When material is needed, such as living earthworms in the dead of winter, or liverworts, or blazing stars, some one is sure to

volunteer to go hunting for them, and usually he brings in the goods.

But the bringing in of class material is the least important result. A plan like this destroys the utterly undemocratic, machine-like course in which exactly the same work is demanded of each pupil, irrespective of his talents and interests. It unites the school and the home by dignifying such tasks as keeping poultry, making hotbeds, gardens, etc. It even furnishes good material for short trips to neighborhood homes, thus giving an added prestige to ordinary daily tasks. I have seen boys positively swell with importance as they showed their chicken houses and explained how they kept their poultry in good condition, their mothers meanwhile looking on with pride. It makes close companions of teachers and pupils by furnishing subject matter for frequent personal interviews. Best of all, it makes biology a matter of importance outside of school hours, awakens a spirit of inquiry and enthusiasm in the pupil, and develops initiative and originality.

I remember when the school practice garden was a bugbear. Now each pupil works out his experiment with the utmost care. The success of the plot assigned to him means his major in botany for the spring semester. I used to have difficulty in laying out the garden, dividing it, and assigning it to the various pupils for their different crops. Now a boy volunteers for the management of the garden as his major, and with only slight supervision from me attends to the thousand and one little problems that arise. Now if two pupils claim and plant the same bed, the case is settled by the garden manager. Of course, the grading of the work remains in my hands.

The slightest job for the laboratory now has its place and dignity. If plants need to be repotted, animals cared for, geraniums slipped, there are always hands ready. Volunteers are seldom lacking when new projects come up for discussion, and many projects originate from the pupils themselves. Only the other day one of my boys who is taking the pharmacy course suggested making a collection of plants and drugs for the laboratory. He had a very good collection nearly finished in a week's time, and, I fear, neglected most of his other subjects meanwhile. This collection of his started us on a new project, which if taken up by other high schools can be made to amount to something worth while. It is that of collecting plants useful for drugs. I see ahead the possible extermination of the bur-

dock and dandelion in this section of the country if the high schools will take up this project. The money obtained could be disposed of by vote of the collectors of the plants. I have already received several letters from drug mills in the vicinity of Chicago offering to take large lots of these dried plants. It is possible, even, that the Red Cross which takes various other contributions, might become interested. There surely is a ripe field for work in this direction. The plants are readily obtained, and the weighing, slicing, and drying, if put in the hands of pupils, offer valuable and interesting work.

The unit system encourages pupils to visit scientific places of interest, to read scientific articles in magazines, to plant ornamental and useful shrubs and trees at home and at school, to raise bulbs, to help in food production, to plan, choose, and even originate problems; in a word, it helps to develop unstultified, wide-awake boys and girls.

Occasionally projects I suggest do not attract some pupils. Not long ago, one of my good students in zoology consulted me on this problem. She had studied my list carefully and had found little work in which she was interested. In fact, some of the problems were repulsive to her, for, she confessed, she could not bear to handle animals. Upon conversing with her I discovered she liked above all to read. That fact opened up great possibilities. She is now delving into Fabre's book, *Science Sketches*, *National Geographic Magazines*, etc., for part of her work, and has taken over the care of our female red-winged blackbird, which we have nursed back to health after it had lost a part of a wing from a stray shot, and which as long as it lives will be a star boarder with us. (The bird, I hope, will develop sympathy in her for the lower animals.) That work in addition to trips to the Academy of Science, Rothschild's aquarium, etc., will easily net her her twenty-five units, and she has not had to choose work which was distasteful to her.

Many cases like this are worth the solving, for when pupils know they are doing work because they chose it, the standard is raised, and the quality of work done is of necessity greatly improved. One encouraging fact about the unit system is that the pupils seldom cease doing their elective work when they have earned the required number of units. Common questions in the laboratory are, "If I collect twenty kinds of wood, how many units will it be worth?" or "Could I do field work by myself for units?" Once or twice I have had a misgiving about my unit

system. A unit has seemed to assume almost the nature of a bribe. I have shut my eyes to that possibility, however. Even a bribe may be moral if it develops enthusiasm for the good things of this life, and surely the innocuous unit slip has accomplished much in this direction.

In the hope that my "Unit System" may be helpful or suggestive to other teachers I am enclosing a list used by beginners in botany this semester.

BOTANY—SEPTEMBER, 1918.

(25 *Units Required of Each Student.*)

MAJORS (10 *units each*):

1. Collection of 20 weeds, scientific and common names.
2. Collection of 15 fall flowers, 10 composite, 5 simple.
3. Collection of 15 leaves and twigs (winter) from trees, scientific and common names.
4. School garden work. *Register now.* (6)
5. Indoor garden work. *Register now.* (2)
6. Collection of 25 fruits, classify and label.
7. Collection of 20 woods, names and uses.

MINORS:

4 experiments performed in laboratory. (4)
10 garden pests, labels and means of combating. (6)
Trip to museums showing botanical collection, notes. (3)
Trip to Garfield Park Conservatory, notes. (3)
Collection of 10 fruits, classify and label. (6)
Collection of 8 composite flowers in herbarium, common and scientific names. (4)
Collection of 10 woods, names and uses. (4)
Planting trees, Arbor Day. (1-5)
Care of plants in laboratory, 1 month. (3)
Starting and maintaining an aquarium in laboratory, notes. (4)
Making infusion culture of bacteria, notes. (3)
Short themes on interesting topics. (1-5)
Lectures on botanical subjects, notes. (1-5)
Civic survey of weeds in block in which you live, diagrams, charts, photographs, etc. (3)
Planting fall bulbs, 3 methods, notes. (3-6)
Slipping geraniums, begonias, etc. (1-3)
Specimens brought for class use. (1-2)
Collection of 15 lbs. of burdock or dandelion roots. (5)
Preparation of home garden for next spring. (3)
Plant parsley for winter use (in school or at home). (1)

NOTICE.—Select some elective work which may be considered war work or conservation work.

LIST OPEN TO ADDITIONS.

HOW CAN SEX EDUCATION BE MADE A PART OF BIOLOGY?[1]

By Edgar F. Van Buskirk, M. A.,

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Sex Education.

1. Scope and Limitations of Biology as a Means for Sex Education.

The term "sex education," as here used, I understand to mean that education which helps in assuming a normal, wholesome attitude of mind toward sex problems. We are concerned primarily with a study of sex in its relation to the normal child, not the abnormal one. The abnormal child should be treated by the psychological expert, and not by the high school teacher. The problem for us to consider is—what can biology contribute to the sex education of the normal child?

You will notice that I said "contribute." For it should be understood that biologic facts in themselves do not necessarily constitute sex education. Biology does, however, furnish a very important body of knowledge upon which can be built the superstructure which we have termed "a normal, wholesome attitude of mind toward sex problems." Especially is this true if this knowledge is tied up with moral teaching such as can be given in courses in English, civics, and physical education. Sex education must be vitalized and given meaning by the teacher, not so much by *what* he says, as by *how* he says it. Sex education is largely a matter of instruction in ethics, and there is much truth in the idea that morals are "caught" and not taught. Training in morals, however, can be made to assume added significance if the commonly accepted standards of morality can be seen to be in harmony with the working of natural laws. In this connection, biology can be made to contribute vitally to sex education. If, for example, biologic facts indicate that beneficial results follow the actual incorporation into one's

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[1]This article is published by permission of the Surgeon General of the United States Public Health Service. The war has shown the need of combating venereal diseases in civil communities. A great factor in the ultimate solution of this problem is wholesome sex instruction in the schools. For the purpose of helping to put sex education in its normal place in the secondary school curriculum, a series of state high school teachers' conferences are being held under the joint auspices of the United States Bureau of Education and the United States Public Health Service. The conference at which this paper was presented was the fourth in the series, and was held at Washington, D. C., January 10 and 11, 1919. Other conferences have been held in Philadelphia, New Haven, Newark, Raleigh and Cincinnati.

life of the commonly accepted moral standards concerning continence and monogamous marriage, and that a violation of these standards often results in harm to the individual, and to society, biology will have made a real contribution to sex education. That there are opportunities in biology for this kind of teaching, there can be no doubt.

II. Guiding Principle To Be Used in Selecting the Biologic Content of Sex Education.

The guiding principle to determine the amount and kind of instruction that a teacher may beneficially give, should be the amount of information which the pupils possess, or think they possess, concerning sex. Most boys and girls of high school age have a considerable fund of information upon sex, but it is largely distorted and untrue. As an illustration of an idea that has been placed in the minds of some youths by degenerate companions, let me mention one question which has been put to me, not once, but several times, in one form or another. One boy put a question to me something like this: "Is it true, as I have been told, that the fluid produced by the reproductive organs is like the mucus coming from the nose, and as such should be expelled from the body?" When it is known that such questions as this are not uncommon in the minds of first-year high school students, is it not high time that some one with authority should set them straight? *Sex education in high schools should aim primarily to correct mistaken or distorted ideas rather than to impart new facts.*

The psychology of sex instruction differs from the psychology of most science instruction in the high school. In most biology work, one of the most important aims is to awaken interest and lead to experimentation. The exact opposite of this is the aim of sex instruction. A very active interest already exists in the subject, and the teacher should try to satisfy the normal questionings that arise in the child's mind without, at the same time, exciting curiosity. There are two extremes to guard against: the one, giving too little information and thus failing to meet the issues involved; the other, giving too much. It is a wise teacher who can discern how far to go. The definite suggestions which follow concerning the content of sex instruction for freshmen in high school presuppose that the class is segregated according to sex. It is based upon ten years' experience in teaching approximately 3,000 first-year high school boys.

III. Correcting Mistaken and Distorted Ideas.

1. *Dispelling the Idea That There Is Something Inherently Unclean in Sex.*

In considering the ideas that need to be corrected, let us first take up one which is probably the most common: namely, that sex matters are necessarily unclean. If the pupils are brought to see that this is untrue, a great forward step will have been taken. Biology can help here.

The study of the reproductive organs of flowers and the processes of reproduction in some of the lower forms of life furnish a splendid background for the study of human reproduction. The pupils should learn that certain parts of flowers make sperm cells and other parts egg cells, and that these cells must unite to produce a new living plant. No one need tell them that flowers are clean. They know that. Thus they will be getting fundamental knowledge which will assist them in taking a normal attitude of mind toward the study of reproduction in animals and human beings. The study of seeds should be correlated with the study of eggs of animals. They should be taught the fundamental likenesses in the development of the embryo plant in the ovule and the embryo animal in the egg. To do this, it will be necessary to learn about the division of cells. At this point there may be introduced a study of the method of reproduction in the very lowest forms of life, such as occurs in bacteria and one-celled animals, where a simple division of the cell results in the production of new individuals. As a stepping-stone to the subject of reproduction in higher forms of animals, a study of the reproduction of fishes is excellent. Thus after it is learned that eggs of the female fish upon being deposited in the water are fertilized by the spermatozoa of the male, it will be easy to teach that in the case of birds and mammals, new individuals are produced by a union of sperm and egg cells in the body of the female.

This study of reproduction will result in giving a decent vocabulary to the pupils. They should also be impressed with the wonderful nature of the whole process. If this subject is properly taught, a reverent attitude of mind towards it will have been created. The pupils' attention may very well be called to the fact that not even the greatest scientist understands the changes which take place when new living things are produced. They should also look upon reproduction as one of several physiological activities, several of which they have probably already studied.

The effect of this kind of instruction as I have seen it work out in many classes, is that gradually those pupils who at first show a tendency to treat the subject lightly soon become accustomed to using such terms as eggs, sperm cells, and fertilization, and use them in the same manner that they would any other terms relating to the study of biology.

2. *Telling the Truth About Venereal Diseases.*

It is not infrequently believed by young men that venereal diseases are of slight consequence. Very few young people of either sex have received positive information from authoritative sources regarding the nature and possible effects of gonorrhea and syphilis. Let us state at the very beginning that it is unwise to emphasize this subject in the first year of high school. Probably all that need be said will not consume more than five minutes, provided the pupils have already in their minds a background of information concerning the general nature, spread, and means of prevention of a few other common diseases.

After learning about some of the fundamental facts concerning the most common diseases of (1) the respiratory system, such as consumption, diphtheria, and pneumonia, (2) the digestive system, such as typhoid fever, and (3) of the circulatory system, such as malaria, it is in the natural course of events to study the most prevalent diseases of the reproductive system—gonorrhea and syphilis. Thus, it will be apparent that there are avenues for the entrance of pathogens through the tubes of the reproductive organs which open on the exterior of the body, just as the nose and mouth furnish a means of access for the entrance of disease-producing agents to the respiratory and digestive systems. It will further be understood that when the agents producing venereal disease enter the body, they will set up an infection with typically characteristic symptoms.

Attention should be called to the fact that gonorrhea and syphilis are very seldom contracted in any other way than through sexual intercourse with a diseased person, and that practically all women who permit promiscuous intercourse have one or both of these diseases during their careers. Knowing that typhoid fever and some of the respiratory diseases are frequently spread by human "carriers," who themselves are well, the pupil will understand how gonorrhea and syphilis may be contracted from persons who give no outward evidence of being sick.

A few facts about the most common possible effects of these diseases may be mentioned. Thus, it is desirable to state that

blindness in new-born babies, invalidism of women and sterility, may be caused by gonorrhea, and that insanity and death may follow an attack of syphilis. Attention should very definitely be called to the fact, however, that (1) although no positive prevention of these results is known, nevertheless venereal diseases do not always produce such effects, and (2) these results are produced in other ways than from veneral diseases. In connection with syphilis it is well to call attention to the fact that it is occasionally spread innocently. This is largely because the pathogen causing this disease can remain alive for a longer time outside of the body than can the gonococcus. Thus, by means of shaving utensils, drinking cups, etc., used by an infected person, and then used by a well person, the germs of syphilis may be spread and enter the body through a very slight break in the skin.

Another fact which should be mentioned is that these diseases are usually curable if promptly and properly treated long enough, although it is often very difficult, if not impossible, completely to eradicate them. Thus many men, thinking themselves cured, have been rudely awakened to the fact, perhaps years after, that the pathogens were merely "sleeping," so to speak, in their bodies. In such cases the man may infect his wife, who, in turn, may transfer the germs to the eyes of the baby during birth. This is an instance of how these diseases make not only the one who infringed the accepted standards of morality suffer, but, in addition, those whom he holds most dear.

How do pupils react to this kind of instruction? It has been my experience that it is exceptional to find a single student whose face does not indicate not only that he is very much interested, but also that he is taking a very serious attitude towards the question. I have had many expressions of gratitude on the part of pupils, and many statements, entirely unsolicited on my part, which would indicate that in their opinion this study was part of the most vital and helpful of any in the course. I shall simply mention one instance. It is the case of a boy who afterwards entered the navy and who wrote to me that the instruction he had received in the classroom had "kept him straight," in spite of the fact that many of his companions were not living clean lives. He added that several of them were suffering from the results of their lack of self-control, at the very time that he was writing. In addition to leading a clean life this young man was representing his battleship on its basketball team and was industriously improving his mind, as well.

3. *Telling the Truth Concerning the Physiological Changes of Puberty and Adolescence.*

Although the essential facts regarding venereal diseases should be told pupils of high school age, nevertheless, this teaching does not constitute the body of knowledge that is of greatest significance to most of them. Probably one of the most misunderstood and distorted phases of the sex question in the minds of young people relates to the physiological changes taking place in their own bodies. A girl should be taught about the significance of menstruation and the proper care of the body during that period. Boys should receive instruction about wholesome reaction to sex feelings and the phenomena of nocturnal emissions. A warning should be given against "quack" doctors. The idea that is still quite prevalent of the existence of a "sexual necessity" should be exploded.

A few facts about internal secretions should be included in the course. The results of castration are of great significance in throwing light upon the action of the internal secretion made by the testicles. The effect of "altering" the young bull, stallion, rooster, cat, and human being, has been demonstrated many times. The internal secretion manufactured by the interstitial cells of the reproductive organs results in producing the so-called secondary sexual characteristics, and is also potent in developing the virile qualities which make for courage, strength, and success in life. It is a well-known fact that self-abuse weakens these same characteristics. There is therefore reason for believing that either the production or the proper functioning of the internal secretion made by the reproductive organs is interfered with as a result of masturbation. In this way, a strong positive appeal to lead a clean life can be made, especially to boys who desire to excel in athletics and manly qualities; and what boys do not?

One of the questions which is apt to trouble youths is the so-called "nocturnal emission." Here, the "quack," if the opportunity offers, will make it appear that very harmful results will follow what is usually simply a normal functioning. The youth should be made to understand that if it does not occur oftener than once in ten days or a fortnight, probably no harm results, and that such an experience is common to most young men. Also, the biology teacher has the opportunity here of showing the interrelations of parts of the body, such as the possible effect of overeating or eating just before retiring, in produc-

ing "nocturnal emissions." The effect of the mind upon the other parts of the body should also be illustrated, and it should be made clear that the boy who wishes to develop his full powers will not fill his mind with sensual thoughts that may be produced by vulgar pictures or listening to obscene stories.

A word as to the effect produced by this kind of information may not be amiss. There comes to my mind a case which is typical of many others. A boy wrote to me after the end of a school term that the information concerning the effect of masturbation had made him decide, as an experiment, to try to give up the habit. He explained that he had contracted it as a result of associating with a group of "dirty fellows"; that he found it very hard to break away from, but that he had finally succeeded in so doing. As a result of his self-mastery he soon improved in health. His statements brought to my consciousness the fact that he had improved markedly in appearance, in carriage, and in his school work. There could be no doubt that this boy had been helped. Another wrote to me that as a result of what he had learned in the classroom he had been led to have a frank talk with an older brother who corroborated the facts brought out in the classroom, and that decidedly beneficial results to himself followed. These are typical of many cases that have come to my attention.

IV. Adding to the Pupil's Fund of Knowledge.

1. *Fundamental Principles Concerning Heredity and Eugenics.*

Although it probably is unwise, because too difficult, to enter into a detailed study of heredity and eugenics with freshmen in high school, the fundamental principles are worthy of consideration and can be understood. The boys and girls are not too young to begin to think a little about the future when they themselves will, in all probability, be parents. It is worth while for them to realize that their present thoughts and actions will greatly help to determine what kind of men and women they will become and what kind of homes they will one day help to make.

An elementary study about the methods of plant and animal breeding will be worth while. A study of the factors involved—heredity, variation, selection, and control of environment, can be put into language that is intelligible to the high school boy and girl. Luther Burbank's experiments are very interesting in this connection. Attention should be called to the fact that the same principles which apply to plant and animal breeding are also true for human beings—although of course, exactly

the same kind of artificial application of these principles could not be recommended. Instances may be mentioned to indicate the ways that these natural laws operate. A study of the "Kallikak" family and the descendants of Jonathan Edwards are cases in point. Even a study of the principles of the Mendelian law, explained in a very simple manner, can be understood by the pupils. A knowledge of these things will help to produce an attitude of mind that ought in many cases to influence them later in what may be merely a subconscious way for their own future good. As the pupils get older a fuller treatment of the facts which relate directly to the sociological aspects of the question will be better appreciated. Since, however, most of the first-year students will probably not have the opportunity of studying these facts later, some reference should be made to them even in an elementary course.

V. The Solution to the Pupil's Sex Problems.

The question of prophylaxis seems to me to be one that ought to be avoided in the classroom, especially when freshmen are concerned. It may be brought up by the exceptional pupil and then a personal interview can be arranged. So much may be said for and against this treatment that it would be unwise to go into a discussion of its merits and defects here. The continent life should be held up as the only safe and right course to follow.

The solution to the problem rests in the banishment, as far as possible, of sex thoughts from consciousness. After the pupils have obtained in an authoritative manner information concerning questions which they have a right to have answered, the very best use that can be made of such information, paradoxical as it may seem, is not think about it. That, of course, is not altogether possible, but it is possible very largely to put sex thoughts into the background of one's consciousness, and this is what is meant. That there is only one way to do this should be made very clear—namely, to substitute pure for impure thoughts, noble for ignoble ideas. The teacher can uphold the single standard of conduct for both men and women. He can instill into the minds of the boys a chivalrous attitude towards girls by suggesting to them, largely through his own conduct, that they should treat all girls the way in which they would have men treat their own sisters or mothers. On the girls' side, they should be warned against the young men who would treat them in any way that they would not care to tell their mothers about. They

should also know that usually young men have stronger sex feelings than young women, and that girls should be modest in actions and dress. After having had a course similar to the one outlined it should become apparent to the pupils that such standards of conduct are in harmony with natural laws.

Finally, the boy or girl who becomes so much interested and absorbed in healthful play and work that there is no time to give to sex thoughts, has found the solution to the problem. This is the heart of the whole matter. To stimulate interest in good reading, debating, athletics, and all forms of healthful outdoor activities, is one of the greatest things that a teacher can do. If the teacher, himself, can participate in such activities or help direct them, he will supplement in a very vital manner his sex instruction.

WORLD MINERAL RESOURCES.

In geology there is no political boundary. Geologic formations extend beneath frontiers and fortresses, and ores and other useful minerals are deposited in like manner from continent to continent. Accordingly, in anticipation that the United States Geological Survey (Department of the Interior) would be called upon for information regarding the mineral deposits and production of countries other than our own, several of the Geological Survey specialists in the study of the different kinds of mineral deposits began last year, as a preparedness measure, the compilation of such data. The results of this work more than fulfilled the expectations, and the demands for the information became so numerous and urgent as to require that the work be placed in the hands of a carefully chosen committee, each member of which is a specialist in his subject. Under the direction of this committee the compilation went forward in a comprehensive and thorough manner. In furnishing such information to the various war organizations the Geological Survey only more fully performed its work as the American bureau of information regarding the geology and mineral resources of the world.

MONTANA SCHOOL LAND EXCHANGED.

The President has signed a proclamation eliminating more than 100,000 acres of timbered land from the Blackfeet and the Flathead National Forests, Montana. These lands carry 618 million feet of timber.

On account of the establishment of the National Forests in Montana, the state was unable to secure title to the unsurveyed school sections 16 and 36 within the forests. By this proclamation forest lands equal in area and value to the timbered school sections which have become permanently part of the National Forests are made available to the state in solid blocks. In exchange for the nontimbered school sections Government lands of similar character in the eastern part of Montana have been selected by the state.

The exchange of lands is advantageous both to the United States and to the state of Montana, for the holdings of each thus become consolidated and easier to manage.

The eliminated lands were selected for the purpose after extensive cooperative field examination by the state of Montana and the Forest Service, with the approval of the Secretary of Agriculture.

THE CASE METHOD OF TEACHING MATHEMATICS.

By G. A. Miller,
University of Illinois.

Reform and progress were never before so persistently discussed by teachers. Unfortunately, the majority of the supposed recent reforms and improvements turned out to have little merit except in the hands of the enthusiastic reformers themselves, where the enthusiasm and not the reform was responsible for the increased success. Hence we naturally take a deep interest in reforms which endure even when they relate to other fields of teaching. Such a reform appeared during the last half century in our law schools, and is commonly known as the "case method" of teaching law.

This reform in teaching is the more interesting to us because it is American, having been inaugurated by an American professor, C. C. Langdell (1826-1906), at an American university to meet the peculiar needs of American students. To some of us it may also be interesting to note that it was inaugurated by a man who had not made a specialty of the study of pedagogy but who was inexperienced in teaching and whose practical knowledge of his subject and deep interest in the practical development of his students constituted the main teaching qualifications. The rapidity with which the case method of teaching law spread from Harvard University and was adopted by leading law schools of our country is one of the strongest evidences of its intrinsic merits, and teachers along other lines may well inquire whether this method has elements which could profitably be adopted by them.

A superficial consideration of the matter might lead the mathematics teacher to expect little help in this direction. The case method is acknowledged to make the work more difficult for the student than the old methods of instruction employed in the law schools. As mathematics teachers we are perhaps too much inclined to look for reforms which will make the work easier for our students. Moreover, the case method of law instruction, called by its author the *Socratic method* or *Scientific method*, seems to have much in common with methods employed earlier in the teaching of scientific subjects. In fact, it has also been called the *laboratory method* of teaching law, and laboratory methods of teaching mathematics in their extreme form have been tried by mathematics teachers and have been found impracticable.

Notwithstanding these untoward superficial indications, the teachers of mathematics might reasonably be inclined to look deeper into any reform in teaching which has proved in another field to be real and fundamental. Probably many of us, possibly most of us, have been very unfavorably impressed by the many loudly heralded reforms in the teaching of our own subject, which proved to be in reality nothing new. Even at the present time we find ourselves in the midst of so-called reforms relating to the fusion or union of mathematical subjects, and the President of the Carnegie Foundation for the Advancement of Teaching recently remarked that "algebra, coordinate geometry, and the calculus are not separate studies, but merely parts of the one subject of mathematics."[1]

The fusion of mathematical subjects into one course is at best trivial. It is neither new nor fundamental. Everyone knows that mathematics is one subject, but for convenience of study we have to consider bits of it at a time. The mathematical loaf has to be cut into slices before we can eat it comfortably, and there is not much use in quarreling about the best shape or size of the dish or dishes in which these slices are served, as long as they are reasonably attractive. During last summer one of our leading mathematicians spoke to me about one of the most successful among the modern combined mathematical textbooks, saying that he liked the trigonometry part of it so well that he suggested to the publishers to bind this part separately for use as a textbook in his own classes. How can its being bound separately affect seriously its usefulness as a textbook?

Combined textbooks seem to be strongly endorsed, in the *Bulletin* to which we referred, in the following words: "The splitting up of mathematics into separate courses is itself a source of weakness from the standpoint of the student's needs. He needs not studies nor recitations in these artificial divisions of mathematics, but a single course in mathematics illuminated and made alive at every step by applications in the solution of actual problems." The high authority of the author of these statements may lead many officials in our engineering schools, as well as other educators, to assume that they relate to something of great importance. Not much reflection is necessary to convince one of their triviality.

On the other hand, the principle involved in the case method

[1]"A Study of Engineering Education," the Carnegie Foundation for the Advancement of Teaching, *Bulletin Number Eleven*, 1918, p. vi.

of teaching is fundamental. This principle is that the student should deal with special concrete cases before he begins to generalize, and he should do his own thinking. In mathematics it corresponds to the problem method of teaching, provided the problems are real and touch the interests of the student. Hence the case method of teaching was used by mathematicians long before it was adopted by the law schools. It is, however, true that it is only within the last half century that we have emphasized it sufficiently, and the textbooks of the Wentworth's series, especially the geometry, were perhaps comparable to those which were adopted about the same time in our law schools,[2] although the change in teaching affected by the former was not nearly so radical as that affected by the latter.

Just as the problem method of teaching mathematics has its drawbacks, so the case method of teaching law has some disadvantages, which were noted in the report on the subject made by Professor Redlich, University of Vienna, for the Carnegie Foundation for the Advancement of Teaching, and published as *Bulletin Number Eight,* 1914. Problem solving alone is apt to lead to fragmentary knowledge.

Comparatively few students will bridge the gaps between these fragments without the aid of a theoretic treatment in which the general abstract laws are clearly brought out. Whether such theoretic work should both precede and follow the problem work in accord with Professor Redlich's suggestion (page ix) relating to a law course may be questioned. What is commonly done now in American mathematical courses is to mix the two methods and to use problems mainly for the purpose of illustration. In England problems are frequently used also to establish new theorems, which is in closer harmony with the present case method in law instruction.

There is a mathematical knowledge of proofs and a mathematical knowledge of uses. Those possessing the former can talk the better about mathematical subjects and exhibit the broader views, while those possessing the latter excel in dealing with special problems whose solution depends upon dexterity in algebraic or geometric manipulations. The continental mathematical students of Europe excel in the former type of knowledge, while English and American students excel in the

[2]The first book published by Langdell as an aid for teaching according to the case method was *A Selection of Cases on the Law of Contracts,* 1871. The first edition of Wentworth's *Elements of Geometry* appeared in 1878. Originals in geometry appeared first in 1875 among the requirements for admission to Harvard College.

latter. The case method of instruction tends to develop the latter type of students, and hence it is especially popular with those who are mainly interested in the tool feature of mathematics such as our engineers, and, to a somewhat less degree, our mathematical physicists and statisticians.

The fact that the case method of instruction represents nothing that is really new in mathematical teaching may serve to emphasize the great difference between the subjects of the science of mathematics and the science of teaching mathematics. The former of these subjects presents many fundamental discoveries, while the latter presents few, if any, such discoveries. Where can we find in the literature of mathematical pedagogy a discovery comparable with the proof of the Pythagorean theorem, the fundamental theorem of algebra, or Taylor's expansion? About the last of these G. Darboux remarked that "of all the discoveries which mathematicians have made in the course of the nineteenth century the most fertile without doubt is that due to Cauchy, relating to Taylor's series and to the condition of its convergence."[3]

It is true that few teachers of secondary mathematics can hope to advance mathematical knowledge by their own labors, but, even if we cannot make any important discoveries ourselves, it is interesting to work in a field where real discoveries have been made in modern times. For these discoveries will be rediscovered by the student himself and will widen his horizon and quicken his interest in human knowledge. Other things being equal a subject rich in discoveries of permanent value offers the best material for the inspiration and intellectual growth of the student. This furnishes a reason why mathematics maintains such a high position among educational subjects, and why the case method of instruction was adopted so early by mathematics teachers.

The mathematics teachers would naturally be greatly interested in a percentage analysis of the professional equipment of some of the most successful teachers in their field in order that they might have some means of judging how to distribute their time devoted to self-improvement. I do not remember having seen such an analysis and should be inclined to think that it would vary with the grade of the teacher. For the teacher in high schools and small colleges the following distribution might serve as a basis for discussion:

[3]*Oeuvres de Henri Poincare*, Vol. 2 (1916), p. xxiv.

Knowledge of the subject taught, sixty-five per cent.
Knowledge of closely related subjects, twelve per cent.
Interest in and sympathy with students, fifteen per cent.
Theoretical knowledge of teaching, eight per cent.

An illustration of interesting reasoning connected with elementary algebra but not usually found in the textbooks on this subject is furnished by considering the possible sets of n roots of an equation of the form,

$$x^n+a_1x^{n-1}+a_2x^{n-2}+\cdot\cdot\cdot\cdot\cdot\cdot+a_n=0$$

where $a_1, a_2, \cdot\cdot\cdot, a_n$ are real or complex numbers. Since each such root is of the form $a+bi$, where a and b are real numbers and $i=\sqrt{-1}$, it results that one such root may have ∞^2 values and hence there are ∞^{2n} sets of n numbers which are roots of equations of the given form. There is a (1, 1) correspondence between these possible sets of numbers and the ∞^{2n} possible sets of numbers representing the coefficients $a_1, a_2, \cdot\cdot\cdot, a_n$. Relations between these two sets of n numbers throw light on the essence of an algebraic equation in one unknown.

Every algebraic equation of degree n in one unknown may therefore be regarded as transforming a coefficient point of the space of n dimensions into a root point of another space of n dimensions and vice versa, while the totality of the equations of degree n represents an involuntary transformation of pairs of points in two n-dimensional spaces, one being composed of root points and the other of coefficient points. These two spaces may be supposed to coincide if its points are regarded as either root points or coefficient points. In particular, the root points of the totality of quadratic equations, which satisfy the equation $x=y$, correspond to the coefficient points which satisfy the $x^2=4y$, while the coefficient points which satisfy the former equation correspond to the root points satisfying the equation $xy-x-y=0$. The only two points in the plane which correspond to themselves in this transformation are the origin and $(1, -2)$.

The methods of presentation which have become classic as regards elementary mathematics are by no means the only simple methods which are available, and teachers should consider various possible methods even where it is desirable to confine class explanations to a single method. For instance, in analytic geometry it is customary to reduce the equations of the central conics to one of the following three forms:

$x^2/a^2+y^2/b^2 = 1, \quad x^2/a^2-y^2/b^2 = 1, \quad ax^2+by^2 = 0.$

On the other hand, it is somewhat easier to reduce these equations to the form

$ax^2+bxy+ay^2 = c,$

and to note that this equation admits a four-group of transformation just as those given above, and that the properties of the possible curves can readily be studied by means of this form.

In closing I desire to direct attention to the following paragraph found on page 226 of a recent *Bulletin* (1917, No. 27) prepared by R. C. Archibald and published by the U. S. Bureau of Education: "When the courses required for the candidates in different countries are considered, the unenviable conclusion is reached that Australia, England, and the United States are largely in a class by themselves. For in these countries mathematical teachers know practically nothing of their subjects, as they have had no special mathematical training in the universities. Perhaps England is less of an offender on account of the number of trained specialists necessary at schools preparing for scholarship examinations. All other countries require of their professors a more or less broad scientific training, and the minimum mathematical requirement is a knowledge of the differential and integral calculus. Most countries include also among their requirements differential equations, projective geometry, mechanics, and physics. A doctor's degree is required of higher teachers in Belgium, Italy, Netherlands, Spain, and Sweden; and the standards for teachers in France and Germany are certainly not below those for the degree of doctor in those countries (indeed much of the training for teacher and doctor is identical)."

Some of these statements may surprise us, but I presume they were carefully considered and deserve our serious attention. A great advantage of intellectual work is that one enjoys here in a full measure the "freedom of the sees." In pedagogical matters the teacher is frequently not free to follow the paths which are most fully in accord with his views, for, while not every stagnating scholar becomes a pedagogue it is very likely that those who devote themselves mainly to pedagogical questions tend to stagnate as scholars. Fortunately, the supervision which provides a living for these cannot extend to our mathematical insight.

ON THE RELATIONS OF MATHEMATICS TO COMMERCE.[1]

By Robert E. Moritz,

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The request from a body of students in economics and commerce for a paper dealing with the relations of mathematics to commerce is indicative of the awakening interest manifested throughout the schools and departments of commerce in the universities of our country in the more scientific preparation of their students. Courses in the mathematical theory of investment and in statistical methods are being rapidly introduced in a great number of the best types of such schools. It is gratifying to know that the department of economics and business administration of this university is taking an advanced position in this movement not only by offering graduate courses in statistical methods to which are to be added courses in actuarial science in the near future, but by requiring certain elementary courses in the mathematics of investment of every candidate for a degree.

If I had been asked to choose my own subject I should have preferred the title, "The Interrelations of Mathematics and Commerce," for I am persuaded that the two fields are mutually related. I am not certain which is the greater, the debt which commerce owes to mathematics, or the debt which mathematics owes to commerce. The marvelous efflorescence of mathematics in recent times is due largely to the cross-fertilization of mind by mind made possible by the manufacture and dissemination of books and periodicals through commercial agencies. Without commerce in the physical sense there could be but little intellectual commerce, and without this no science, least of all mathematics, could have progressed very far toward its present state of perfection.

This dependence of mathematics on commerce can be well illustrated by certain epochal events in the history of science. In the sixth century B. C. there lived in Miletus the famous philosopher and mathematician Thales, one of the seven sages of Greece. He is equally celebrated for predicting a solar eclipse and for proving that every angle inscribed in a semicircle is a right angle, a theorem that has been called the most beautiful theorem in geometry, comparable to the sun in a firmament in which the other theorems are stars. He seems to have been the

[1]Read before the Economics Seminar of the University of Washington on November 14, 1918.

first to establish geometrical truths by demonstrative reasoning and thus became the founder of the science of geometry. In his early life Thales was a merchant, as sagacious in business as he was afterwards celebrated in science. He is the first man mentioned in history who successfully "cornered the market." The story is told that one year, when the olive crop promised to be unusually abundant, Thales bought up all the olive presses of the district and lent them out at his own figure when they were needed later in the season. Now it is known that his business as a merchant required Thales to travel extensively in Egypt and it is believed that he brought home from that country much of the knowledge which he afterwards elaborated and which enabled him to become the founder of the science of geometry.

The second instance that I shall cite is even more familiar than the first. In the latter part of the twelfth century there lived in Pisa in Italy a merchant named Bonacci who was sent by his fellow townsmen to take charge of the custom house at Bugia on the Barbary Coast. Bonacci had a son named Leonardo, who, like his father, engaged in commerce, and while thus engaged took journeys into Greece and Arabia. He returned to Italy about the year 1200 and shortly afterwards published a famous work called *Algebre et Almuchabala*, now more familiarly known by the name of *Liber Abaci*. It was this book that first explained systematically the Arabic system of numeration and so clearly pointed out the advantages of this system over the Roman system that it was only a question of time until the latter had to make way for it. Of course a change as sweeping as that involved in changing a system of numeration was not effected in a day and without fierce opposition, just as the metric system of measurements, in spite of its manifest advantages, has had to struggle for recognition and is still rejected by the "most enlightened nations" on earth. Almost a century after Leonardo's book appeared, the city of Florence passed an edict forbidding bankers to use Arabic numerals, and as late as 1348 the University of Padua ordered that the prices on books should be marked in "plain letters" and not in Arabic numerals.

Now it is generally agreed that the introduction into Europe of the Arabic notation marked the greatest single advance in mathematics since the foundation of the science of geometry by the Greeks. Both of these advances are intimately associated with commercial activities, as indeed are many others. The

Italian merchants were not only the first to use the new and marvelous Arabic arithmetic, but it is to these merchants also that we owe much of the early improvement and development of arithmetic. The same Florentine merchants who invented double entry bookkeeping systematized arithmetic by dividing its problems into classes such as proportion, interest, discount, profit and loss, etc., divisions which have persisted until the present day. Moreover, they reduced the former twenty or more processes of arithmetic to seven, the same seven which are still taught in every elementary school in America and Europe. Here, by the way, we have a curious illustration of the influence of religion on science. On the authority of Pacioli, a contemporary writer, the arithmetic processes were reduced to seven in reverence to the seven gifts of the Holy Spirit.

But if commerce was responsible for the introduction of the Arabic arithmetic into Europe, this improved arithmetic was no small factor in the wonderful growth of commerce during the thirteenth and fourteenth centuries. Commerce had reached the point where a better arithmetic was indispensable to its further growth, and mathematics supplied the need when it was sufficiently felt. The instrument had been slowly but carefully forged in India and Arabia during preceding centuries and was ready for use the moment the world was willing to avail itself of its service. This is but a single illustration of a long list that could be given in which mathematics anticipated and provided for the future needs of civilization. It was so two centuries later with the invention of logarithms. Science had then reached the stage where it was absolutely necessary that there should be refinements in computation which the ordinary processes of arithmetic could only supply by tedious, time-consuming, and uncertain methods. When this need was clearly recognized mathematics came to the rescue by supplying a new method of computation based on the theory of exponents which had been gradually developing during the preceding centuries.

Just as it is impossible for a person who travels from New York to San Francisco in a Pullman palace car to realize the difficulties that beset such a journey before the construction of the railway, so no one can realize the difficulties that were encountered in comparatively simple calculations before the invention of the Arabic arithmetic. It required the genius of an Archimedes to compute the square root of a number to a moderate degree of approximation. Such computations as are today

performed by the average boy and girl in the grammar schools were beyond the abilities of all but the learned in former days. The skilful handling of figures by the average merchant or banker of today would seem like magic to the merchant of ancient times. It is safe to say that without the improvements in calculation due to the mathematician's skill, modern commerce would be impossible. It is by the aid of mathematics that it is possible for us to keep an account of our mighty commerce with foreign nations, that enables a thousand bookkeepers of the Bank of England to strike the monetary balance of the civilized world. It has been said that skill and accuracy in applying the common rules of arithmetic are as important to modern society as the enterprise and capital of the merchant, or the industry and courage of the navigator.

It requires no lengthy argument to show the importance of arithmetic to commerce, to business, and to economics. That much will be admitted by all. What is not so obvious is that a knowledge of the higher mathematics, or rather what passes for higher mathematics in common parlance, is as essential to the proper understanding and the solution of the great problems of commerce and business today as was the Arabic arithmetic to the commerce of five centuries ago. The theory of interest, both simple and compound, questions in discount, equation of payments, capitalization, valuation of debenture bonds, computation of depreciation and renewals of properties, amortization of interest bearing debts, and that great mass of problems that falls under the head of annuities, all these, when treated in their broader aspects, are not amenable to arithmetic alone but demand a knowledge of a great deal of algebra and a familiarity with the use of logarithms.

Consider for a moment the field of life insurance. The determination of the premiums of the various classes of policies, whether ordinary life, term, or endowment, the computation of legal reserve values, the distribution of dividends, proper methods of loading net premiums, and the ascertaining of the cost of insurance, all these require the use of refined mathematical processes far beyond the mathematics of the high school. The adjustment and graduation of mortality tables, without which insurance would be a gamble and not a business, requires furthermore a thorough knowledge of the theory of probability, of finite differences, and the theory of errors, which in turn involves a knowledge of the differential and integral calculus.

The life insurance in force in the United States alone aggregated over thirty billion dollars before the war and has probably increased to nearly fifty billions through the Government insurance to soldiers and sailors. And yet insurance may still be considered in its infancy. Industrial insurance, disability and casualty insurance, old age insurance, to say nothing of the other manifold hazards provided against by insurance, are just beginning to be appreciated by the general public. When we consider the magnitude and importance of this movement in the present day, those branches of higher mathematics, on which the whole institution of insurance rests, must be given a larger place in the curricula of our schools and colleges of commerce.

Whenever and wherever exact relations are to be revealed and utilized, mathematics is the indispensable tool for which there exists no substitute. In fact, mathematics is, par excellence, that science which deals with exact relations of whatever kind. The discovery and evaluation of exact relations invariably involves computation. In the last analysis the highest branches of mathematics, as well as the lowest, deal with computation. Every theorem, no matter how complicated it may appear on the surface, directly or indirectly simplifies computation and is therefore potentially of direct service to humanity.

It will be admitted that commerce is closely related to economics and vitally concerned in the proper solution of every economic problem. Every adjustment in finance, in transportation, in labor conditions, in production and distribution, in tariffs and taxation affects commercial interests as all others. Let me then point out in this connection certain relations between mathematics and economics which deserve far greater recognition than they have received up to this time. Economics has ceased to be the dismal science brooding over the Malthusian doctrine, and has turned its attention to the scientific analysis of the life of the state. The guiding principle of this new analysis is the law of large numbers which asserts that, however little we may know of what will happen in any particular instance, yet there is practical uniformity in the frequency of any particular event in a great number of instances. This law is the outgrowth of the theory of probabilities and has been verified again and again by actual statistical experience. Nothing seems more uncertain than the destruction of a particular property by fire, hail, or tornado, yet the law of large numbers enables us to provide against just such uncertainties. It enables

us to predict the number of births, marriages, and deaths in a given community, the number of crimes that will be committed during the year, the number of people who will die of typhoid or tuberculosis, the number who will perish by accident on land or at sea. Nothing is too uncertain to escape the lynx-eyed scrutiny of this new analysis.

The raw material on which this analysis works is statistical data, and these are being collected with an enthusiasm that would do honor to the crusaders of old. Not individuals only, but corporations, chambers of commerce, commerce commissions, boards of all kinds and descriptions, and now the Federal Government itself, through a thousand different agencies, is collecting an enormous mass of statistical information in the hope of disclosing the hidden relations that govern economic and social phenomena. Yet how few realize that such material, to be of value, must be properly selected, reduced, correlated, and interpreted by agents who have had the requisite mathematical preparation in the theory of statistics. This information, some of which is collected at an enormous cost running into tens of thousands and even hundreds of thousands of dollars, is as useless in the hands of a statistician unskilled in mathematics, as are the data of an elaborate physical experiment in the hands of a mere mechanic, or the observational data of an astronomer in the hands of a practical seaman. There is about as much scientific value in the average collection of statistical facts as there is in the average collection of insects or flowers of the amateur collector. How many of those who are engaged in statistical investigations could read even the first fifty pages of Elderton's little book on *Frequency Curves and Correlation?*

It is a hopeful sign that there are men here and there who are cognizant of the tremendous aid that mathematics may render to the solution of commercial, economic, and social problems. Says H. G. Wells in his *Mankind in the Making*, "The new mathematics is a sort of supplement of language, affording a means of thought about form and quantity and a means of expression, more exact, compact, and ready than ordinary language. The great body of physical science, a great deal of the essential facts of financial science, and the endless social and political problems are only thinkable to those who have had a sound training in mathematical analysis, and the time may not be very remote when it will be understood that for complete initiation as an

efficient citizen of one of the great complex world-wide states that are now developing, it is as necessary to be able to compute, to think in averages and maxima and minima, as it is now to be able to read and to write."

Thus far I have mentioned only some of the direct relations between mathematics and commerce and allied fields. Such relations appeal most strongly to the average student, yet I would not leave the impression that I consider these the only, or even the most important, considerations which should cause the student in commerce to elect mathematical courses among others in preparation for successful administrative work. There are many indirect relations which time fails me to discuss fully on this occasion. I refer to those habits of thought and methods of work which mathematical studies tend to develop in the student irrespective of the particular subject matter under consideration. Business executives have told me that they prefer assistants who have had considerable mathematical training, not because they expect them to make use of their knowledge of algebra, trigonometry, or calculus, but because men and women trained in these studies are as a rule more methodical, exact, and resourceful—in a word, more efficient— than those lacking such training. This view is corroborated by my observation that business administrators as a rule have mathematical minds even if they have not had much formal mathematical preparation, and by the further observation that a far greater number of mathematically trained students rise to executive positions than the law of chance distribution would seem to account for. An examination of the records of the deans in our universities and colleges justifies in part the exaggerated statement that the mathematical profession is the normal avenue of promotion to these offices.

The reason for the relations just suggested are not far to seek. The effectiveness of an executive or administrator depends on his ability to analyze a problem into its component factors, to single out those factors which are pertinent, and to exclude those which are irrelevant, on his capacity to coordinate and to correlate a number of different ideas, on his power to trace the logical consequences of a course of action, on being methodical, systematic, precise, and accurate in making plans and giving instructions in carrying them out, on his ability to concentrate all his powers in the accomplishment of a given task, in not surrendering to obstacles and difficulties that are not easily overcome, in not

wasting his energies in attempting the impossible, that is, in recognizing when a problem is and when it is not capable of solution or accomplishment. But these are just the abilities which mathematics calls for and which a careful and prolonged study of the subject tends to strengthen and develop. When one reflects what substitutes for these abilities nine men out of ten without training in mathematics have to offer in their place, it must be clear that the student who neglects his mathematical preparation enters the race for success as a business administrator under serious handicaps.

PLANE GEOMETRY FOR THE NINTH AND TENTH GRADES.

By Robert R. Goff,

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It is agreed that:

1. Geometry of the ninth and tenth grades should be adapted to pupils who may or may not go further in school.
2. Two of the important aims in the study of geometry are information and good habits.

Now this information and these good habits are worth getting provided they do not require too great an effort and too much time. In other words, there should be economical study.

In the writer's opinion proofs (1) of first principles, (2) by superposition, (3) by the indirect method take too much time and effort in proportion to their value in the development of good habits. These cases may furnish important information, but their proofs are relatively of little value. Consequently it is suggested that the study of these groups be by drawing and observation.

Among the first principles should be these two theorems:

1. Two circles can intersect in only two points, one on each side of the line of centers.
2. From a point in a perpendicular, only two equal oblique lines can be drawn to the base line, one on each side of the perpendicular.

Of the proofs by observational superposition, there should be six cases; the four fundamental cases of congruent triangles, and two cases of congruent sectors. The two theorems of congruent triangles, not usually proved by superposition, are proved so here by means of the two theorems mentioned above in the first principles.

Of the theorems commonly proved by the indirect method,

only two need be taken, and these not by the indirect method. If two parallel lines are crossed by a transversal, the corresponding angles are equal; its converse. These can well be observed by the sliding of a triangle along a line as a draughtsman does.

All the above principles form an introduction to plane geometry. Following this in the ninth grade, the final aim might be to prove and apply the common formulas of area. This would involve about twenty of the simplest propositions of congruent triangles, equality, perpendiculars, angle-sums, and areas. The Pythagorean theorem might be investigated by means of graph paper; also the area of a rectangle. Finally, there should be many numerical exercises on angle-sums, areas, and the Pythagorean theorem. The number of theorems taken will depend upon the time allowed, but an experimental course is being tried by the writer of about ten weeks.

In the tenth grade, all the previous work should be reviewed in the same manner, and a minimum list of the standard theorems should be inserted at their proper places. This might take about thirty weeks. Here the emphasis is on groups, their summaries, and applications. In other words, one of the aims is to develop habits of systematic effort.

ELECTRICAL SALES FOR 1918.

It becomes apparent that sales of electrical equipment billed in 1918 are not much greater, if greater at all, than those billed during the record year of 1917. In fact, in not a few instances it will be found that gross sales for 1918 are below those for 1917.

If the above is true, then the sales of electrical goods billed in 1918 will probably be found to run around $750,000,000.

A good many reasons can be found for sales not running higher. First, there was not the quantity of new factory space in 1918 that there was for 1917 production. Second, there was less commercial and more government purchasing. Third, the shortage of raw materials and labor reduced production in many lines. Fourth, conservation measures required curtailment in the output of a number of electrical products. Fifth, the signing of the armistice early in November caused a very large reduction in output. Sixth, government prices on raw materials brought lower average prices on certain lines, particularly wire, which has the largest output in dollars and cents of all electrical manufactures.

At the close of 1917 the unfilled orders on hand were very large. Some of these orders have not yet been filled. Unfilled orders now on hand are probably much smaller than they were a year ago. The close of the war brought many cancellations. All government contracts, however, were not canceled. The big government contract for outpost wire, for instance, still remains in the process of fulfillment.

When the new year opens the electrical manufacturing industry will find itself in a better condition to attract business than it has been in for the past two years. Once more it will be able to give service to buyers. —[*Electrical World*.

NOTES ON "BOLSHEVIK MULTIPLICATIONS."

On page 698 of the November (1918) issue of this Journal was printed a short article on Bolshevik Multiplications, with the request that some reader give an explanation of the method. Several solutions have been received. We can reproduce, however, only the following, with an added reverse process.

Where 25 is to be multiplied by 40, the method is as follows, I think, according to the Bolshevik method:

~~40~~	~~25~~
~~20~~	~~50~~
~~10~~	~~100~~
5	200
~~2~~	~~400~~
1	800
	1000

That is, the numbers in the right hand column are doubled and those in the left hand column halved, all fractions being ignored. Then all numbers in the right hand column which tally with odd numbers in the left are added while the others are ignored.

As far as I can see, the principle involved is simply that involved in multiplication, that is, addition. When 25 is to be multiplied by 40, it only means that 25 is to be added 40 times. Now if one will just make a third column to the right of the right hand column above, noting how many times one uses the 25 when one doubles the numbers in the right hand column and then cross out those numbers which tally with the even numbers in the other two rows, one will find that he has simply added 25 forty times.

This will be so with any two numbers that are multiplied together. —FLORENCE E. HOLMES, Wallkill, N. Y.

The numbers formed by doubling, beginning with 1, produce a list of key numbers, thus, 1, 2, 4, 8, 16, 32, 64, etc. These key numbers combine in a systematic way as addends of all other numbers. See the accompanying table. Every number has one, and only one, combination of these key numbers as addends.

$1 = 1$

$2 = 2$
$3 = 2 + 1$

$4 = 4$
$5 = 4 + 1$
$6 = 4 + 2$
$7 = 4 + 2 + 1$

$8 = 8$
$9 = 8 + 1$
$10 = 8 + 2$
$11 = 8 + 2 + 1$
$12 = 8 + 4$
$13 = 8 + 4 + 1$
$14 = 8 + 4 + 2$
$15 = 8 + 4 + 2 + 1$

$16 = 16$
$17 = 16 + 1$

The sum of all the key numbers up to any certain key number produces a number just one less than the next key number in the list. Omitting one or more produces any number between.

To find the addends of any number, divide it by 2, and continue dividing by 2 (casting off any remainders) until 1 is reached. All the key numbers are even, except the 1, therefore, if the given number x is odd, it contains 1 as an addend; but if it is even, it cannot contain 1 as an addend. Therefore,

If x is odd, 1 is an addend, but not otherwise.

If $x/2$ is odd, then 2 is an addend, but not otherwise.

If $x/4$ is odd, then 4 is an addend of x, but not otherwise.

If $x/8$ is odd, then 8 is an addend of x, but not otherwise; etc.

Continue this until $x/y=1$. This / is odd, and therefore y is an addend of x, and the largest one.

In the halving process, the 1 remainder, which is cast off and apparently lost, is really the determining feature; for if $x+z$ is odd, the 1 is cast off, and z is thus known to be an addend of x.

Key Numbers	Multiplicand	Multipliers
1	4 7 5 x	1 3 =
4	1 9 0 0	3
8	3 8 0 0	1
	6 1 7 5 Ans.	

This is the principle hidden in Bolshevik multiplication. For example, 475 x 13 = ? Dividing 13 by 2, we find its addends (see key column) are 1, 4, and 8. (The 6 is the only even number in the multiplier column. That cancels the entire line.) Therefore, (1 x 475) + (4 x 475) + (8 x475) = (13 x 475). Then 475 is doubled down the column. The (2x475) is canceled out because 2 is not an addend of 13, as indicated by the evenness of 6. Using the other doubles as addends produces the desired product.

The column of key numbers is unnecessary for actual solution, but it is enlightening. Our methods of multiplication depends upon factoring while this depends upon addends. With our decimal system of notation, the factoring of ordinary numbers is fairly easy, but with a letter system of notation, factoring requires an expert mathematician. (The factors of many numbers in the millions are yet unknown.) The addend system is a safe method to use for multiplication and division whatever the notation may be, and is doubtless a very ancient method. —MRS. MABEL W. ARLIGH Corning, Calif.

At first glance this method appears to be a rather strange method of multiplication of integers. But a little reflection will show that the principle involved is essentially the same as that underlying the method in common use. The difference lies principally in the fact that the multiplier in the Bolshevik method is expressed in the binary scale instead of the decimal.

Any integer can be expressed as the sum of different powers of the scale 2. For example, the number 40, employed in one of the multiplications exhibited, may be written thus:

$$1.2^5+0.2^4+1.2^3+0.2^2+0.2^1+0.2^0\ ,$$

as it virtually is in the problem, just as in our decimal system the way we write the number 520,403 is the conventional way for writing

$$5.10^5+2.10^4+0.10^3+4.10^2+0.10^1+3.10^0\ ,$$

If either of the foregoing numbers, expressed in the extended forms,

is used as a multiplier, it is evident that the partial products corresponding to the parts having zero as a coefficient are each zero. This explains why those numbers in the right-hand column of the exhibited multiplications, corresponding to the even numbers in the left-hand column, are rejected. They are in effect multiplied by the coefficient zero, while each of the others is multiplied by 1, the only other coefficient we can have in the binary scale system of writing numbers. The only purpose the rejected numbers serve is to preserve an unbroken chain of consecutive powers of 2, concealed, of course, in the successive products.

Though each step involves very simple operations, the method is after all quite cumbersome when applied to large numbers, as will easily be seen if one uses, say, 16,383 as a multiplier.—B. F. YANNEY, The College of Wooster, Wooster, Ohio.

I learned this method some years ago from a teacher at the Francis W. Parker School, Chicago, who called it the Russian Peasant Method.

The method involves finding the addends of a number, rather than its factors. I found that division can be done by reversing the process.

For example,

1599	÷	123	=
		246	
		492	
		984	

Double the divisor, and continue doubling in a column, until you have the largest less than the dividend. (To double 984 would evidently produce a larger number than the dividend.) These are the possible addends of 1599, from which must be selected its exact addends, thus:

1599	÷	123	=
946		~~246~~	
———		492	
615		984	
492			
———			
123			
123			
———			

Subtract the largest addend from the dividend. From this remainder subtract the next largest addend. Continue subtracting the addends in order. If any addend is too large, do not use it, and cancel it out of the addend column. When all the addends possible have been subtracted, if there is still a remainder, it is less than the divisor, and is the real remainder. (This subtracting can be done mentally after a little practice, tor largely shortened.)

Then add up the addend column as a proof. Then build a third column h us:

1599	÷	123	=	13
		~~246~~	—	6
		492	—	3
		984	—	1

Opposite the largest addend, place a 1 in the quotient column. Double it. If the addend opposite the space above is cancelled, write this perfect double just above the 1. If the addend opposite this space is not cancelled, add 1 to the perfect double before writing it. Go up the column, doubling in this manner, and the number at the top will be the quotient. (This quotient column must have an odd number opposite each addend not cancelled, and an even number opposite each cancelled addend.) —MABEL W. ARLEIGH, Corning, Calif.

MINUTES OF THE CHEMISTRY SECTION OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

FRIDAY AFTERNOON, NOVEMBER 29, 1918.

The meeting was called to order by the Vice President, R. W. Osborne. In the absence of the Secretary, the Chair appointed H. M. Mess, Secretary pro tem. Number present, about forty-five.

The following committees were appointed:

Nominating—R. E. Davis, Lane Technical, Chicago; K. J. Stouffer, Wayland Academy, Beaver Dam, Wis.; L. F. Micky, Faribault, Minn.

Resolutions—A. L. Smith, Englewood High, Chicago; S. R. Wilson, Culver Military Academy, Culver, Ind.; Geo. Sype, Austin High, Chicago.

Dr. Wm. D. Harkins (University of Chicago) gave a very interesting address on "The Structure of Atoms, the Evolution of the Elements, and the Periodic System." This paper will appear in full in SCHOOL SCIENCE AND MATHEMATICS. The discussion that followed did not bring out any new points, as it consisted mainly of questions answered by Dr. Harkins.

Mr. H. R. Smith (Lake View High, Chicago), Chairman of the Committee on Advertising for the *Program* of the Association, urged the importance of patronizing the firms whose advertisements appear in the *Program*, and he also requested that the members take every opportunity to let these firms know that their advertisements have been noticed. This will make it easier for the committee to secure the advertisements of these firms for the *Program* next year.

In the absence of Mr. F. B. Wade (Shortridge High, Indianapolis, Ind.), his paper on "The Chemistry Teacher's Opportunity" was read by Mr. C. E. Osborne (High School, Oak Park, Ill.).

SUMMARY—Teachers should direct the attention of their pupils to the great need of scientifically trained workers in agriculture and the industries. Special attention should be given to pupils showing marked ability to induce them to enter higher schools. High school students should not specialize in one science, but should become acquainted with several sciences. Those who cannot afford to go directly to college can often be placed in laboratories as assistants. While the routine work they are able to do is valuable training, they must be urged to regard this work as only a means of earning money with which to continue their education. Membership in such organizations as the American Chemical Society is useful to a teacher as it gives him an acquaintance with the heads of laboratories. In this way he learns of opportunities to place pupils who need work. Usually no effort can be made to train pupils for any special kind of work. A thorough training in the fundamentals of general chemistry will enable a bright student to make himself useful in any kind of laboratory.

DISCUSSION.—Mr. C. E. Osborne: The best part of chemistry training in high school is in teaching common honesty, telling exactly what is observed. Also that the world is not the result of chance; there must be a Master Mind back of the wonderful system and order that a study of science reveals. The teacher should not advise students to become chemists; let them decide. War has provided a wonderful opportunity to make chemistry interesting to pupils. Articles appearing in papers and magazines should be brought to their attention. The teacher can give talks to classes or school assemblies on such topics as, "How Science Has Helped to Win the War," "How Chemistry Has Helped to Win the War," "Gas Warfare and High Explosives." Exhibits always arouse great interest, and so far as possible should be arranged by the pupils them-

selves. Oak Park High School has an annual "Open Night" for the community, and the chemistry exhibit always draws large crowds.

Mr. R. W. Osborne: At Francis Parker School one period each week is devoted to "Current Events," and the school is divided up into groups according to the chief interests of the pupils. A large group is interested in chemistry, discussing explosives, star shells, war gases, etc. Occasionally this group takes charge of the school assembly, interesting papers being read and experiments performed.

Mr. L. L. Hall, Morgan Park High, Chicago, replying to a question as to the remuneration of the average person in commercial chemistry, said that he had investigated the situation at the Union Stock Yards, Chicago, and had found that in each laboratory there are only two positions which are worth while—head of the department and first assistant. However, many young college graduates come in for a year or two for the experience and then take good positions outside, while some are transferred to other departments as assistants to the heads, and are thus in direct line for promotion.

Mr. W. S. Stevens, Lockport, Ill.: Only two per cent of all those entering the Stock Yards laboratories become heads of departments.

Mr. R. W. Osborne called attention to the fact that this matter had been fully discussed in *The Chicago Chemical Bulletin*, published by the Chicago Section of the American Chemical Society, 9 So. Clinton St.

Mr. R. E. Davis, Lane Technical, Chicago: Last year twenty pupils were placed in laboratories, mostly routine work, on the coöperative plan, two students working alternately on the same job, morning and afternoon. Requests for such "teams" have come from the outside, neither teachers nor pupils going out after them.

Mr. J. E. Coe, Lake View High, Chicago: There are many places open in summer, giving the pupils a chance to find out whether or not they like chemistry well enough to make it their life work.

Mr. S. R. Wilson, Academy, Culver, Ind., said that he found that the use of a loose-leaf manual cut down the amount of writing done by the pupils, as it is not necessary for them to write out the procedure. This makes it easier for the teacher to read over the notes. Under the old way, the writing consists largely in copying directions from the manual, involving little thinking, and it is practically impossible to have the final record made in the laboratory on account of lack of time. With the loose-leaf manuals there is less writing, more time for thinking, and the final record can easily be made in the laboratory while the experiment is being performed.

Dr. A. L. Smith, Englewood High, Chicago, in answer to a question, stated that students ought to work singly whenever possible, but that it is sometimes necessary to have them work in pairs to save material, lessen quantity of objectionable fumes, or on account of difficulty in working the experiment singly. Whenever possible the residues should be saved; advanced students may work them up for extra credit. Potassium chloride and manganese dioxide may be recovered from the oxygen experiment, zinc sulphate from the hydrogen experiment, ferrous sulphate from hydrogen sulphide preparation, etc.

The Chairman announced that there would be no chemistry show on account of the absence of Miss Caplin, and that if the show was to be continued in future meetings, provision would have to be made for more help in its preparation.

SATURDAY MORNING, NOVEMBER 30, 1918.

The Committee on Nominations reported as follows:

For Chairman—S. R. Wilson, Academy, Culver, Ind.

For Vice-Chairman—Albert L. Smith, Englewood High, Chicago.

For Secretary—H. M. Mess, Senn High, Chicago.

It was moved and seconded that the Secretary be instructed to cast the ballot of the section for these candidates. Carried.

The Committee on Resolutions presented the following report:

"In behalf of this section we wish to express our sincere thanks to the authorities of the University of Chicago for the privilege of meeting here. The numerous advantages which this University affords cannot be excelled, and in addition the cordial spirit of hospitality which is always in evidence makes this an extremely pleasant place for our annual gatherings.

"This section also wishes to express its appreciation of the opportunity to hear Dr. Harkins in his most able address on the modern theory of the constitution of matter and energy, which represents years of careful research and study.

"The committee was asked to suggest a topic for the next meeting. We would recommend that the section discuss 'The Work of the Chemist During and After the War.'

"Albert L. Smith.
"Geo. Sype.
"S. R. Wilson."

Mr. H. R. Smith offered the following additional resolutions of the "Aims of Chemistry Teaching," and they were accepted by the committee:

I. To teach our pupils to acquire the scientific attitude of mind as a habit.

II. So far as possible, all ideas should originate from facts, actual contact with material and events. Dr. Bailey of Cornell University says: "To find the facts and know the truth."

III. The laboratory is the world of material and events in miniature, and should be made as real as possible.

1. A problem from life.
   (*a*) Field trips.
   (*b*) Problems brought to the laboratory.
   (*c*) Experiment devised to illustrate a principle.
2. Applications.
   (*a*) Studied by laboratory method.
   (*b*) Studied and material exhibited.
   (*c*) Just talked about.

IV. In teaching science we should think of knowledge in terms on life and living things and not of books.

V. Since the laboratory work is the vital part of the student work, all material and methods should be so organized that the teacher can give the major part of his time to actual instruction in the laboratory, and not to the merely mechanical parts of laboratory procedure.

The adoption of the resolutions was moved, seconded, and carried.

Mr. B. S. Hopkins, University of Illinois, read a paper on "Teaching of Chemistry in the Laboratory," which appears in full on pages 295-302 of this Journal.

Discussion.—Mr. H. R. Smith: If a pupil can write a perfect record of an experiment without understanding the experiment, something is wrong further back, probably with the experiment itself. By passing among the pupils while they are at work, the teacher can see that they do understand the experiment and make a proper record of it. A way to avoid drudgery in correcting laboratory records is to return the papers the next day in the quiz, discuss the experiment, and have the pupil make his own corrections under the teacher's supervision.

Mr. Hopkins, answering a question as to whether all color changes were signs of chemical actions, said that they probably were, and then remarked that notebook records could not always be relied upon as showing what a pupil got out of an experiment. A good student, a girl, had a perfect record of a quantitative experiment on gases. A little quizzing showed that she did not understand the experiment at all, and that the whole record was the work of other students. A teacher should try to avoid a direct answer to pupils' requests for information, but should help the pupils to answer their own questions by asking them other questions. The pupils should correct their own records, in the laboratory if possible.

Mr. Geo. Sype, Austin High, Chicago: The method of laboratory teaching outlined by Mr. Hopkins could be worked if one had classes of ten or fifteen, but not with classes of thirty. Why not have the questions in the manual?

Mr. R. E. Davis, Lane, Chicago: The classes at Lane are large, and Mr. Davis goes about the class during the laboratory period asking questions, but examines the records out of class. He assumes good records to be O. K., but when suspicious of any pupil, has a conference with him. He indicates errors on the record sheet, but the pupil makes the corrections. The laboratory work should be regarded as supervised study.

Mr. Hopkins: It is a good plan to have the questions in the manual, but it is better to ask them, for many pupils get help from old notebooks of former pupils.

Mr. H. R. Smith: The pupil should know what he is going to do before he begins an experiment. Previous study of an experiment is not objectionable, and becomes highly desirable if he can be given material which will serve as an introduction to the experiment and give him the information needed to work it intelligently, but will not give him the results of the experiment itself.

The paper on "Laboratory Organization" by Miss Kate McDermott, South High School, Minneapolis, Minn., was read by Mr. S. R. Wilson.

Summary.—The object of laboratory work in chemistry is threefold:

First, to have the pupil observe some of the basic facts and processes of chemistry by performing certain experiments himself. To attain this result it is necessary that each pupil do the laboratory work individually, writing up his record as he works, and later repeating any work in which he failed to secure the proper results.

Second, to have the pupil learn to think and learn to work independently when directions are given. The instructor should always be present during laboratory work, supervising the work of each pupil, asking questions to help pupils get back on the right track when they go astray, and seeing that each pupil is doing honest, independent work.

Third, to have the pupil learn to do things neatly as well as to get the required results of the experiment. The instructor should have his laboratory thoroughly organized, with a place for everything, and should take enough time each day to see that the part of the laboratory for which he is responsible is in order. Each student should have a certain place to work and should be assigned a certain drawer in which to keep the apparatus for which he is individually responsible. He should be carefully instructed as to the uses and care of the different articles, and then the instructor should insist that the pupil take proper care of his own apparatus, of his desk, and of the laboratory generally. For this purpose each pupil should have two towels or cloths, and a counter brush and dustpan should be kept in a convenient place.

The instructor should always have out the materials needed for the work of the day, and, if the manual does not give a list of materials at the beginning of each experiment, he should go through his own copy and make such lists for his own convenience.

The instructor may keep track of the various materials and apparatus and find out how much of each to order, in the following manner. In a good-sized book arrange alphabetically the names of apparatus and of chemicals separately, with the size or grade of each. Cut down the next two or three sheets so that they extend just to this list. Narrow vertical columns should then be ruled off on these pages. In the first column write the approximate amounts of each article on hand at the end of the year, in the next column the amount ordered for the next year, in the third column the amount on hand at the end of the second year, etc. From this it will be easy to figure how much was used and how much to order. Such a book will also help in making out the annual inventory required in some schools.

Discussion.—Mr. H. R. Smith: The instructor can do better laboratory teaching, and do it much more easily, if the entire class is working on the same experiment. The bright pupils may be kept busy by optional parts of the experiments, or the experiments may purposely be made so long that only the brightest pupils can finish them. If the essential parts of the experiment are put at the beginning, the others will not lose anything important. The grade given can be made dependent on quantity of work done as well as on quality. The final record should be made in the laboratory at the time the experiment is performed. With a loose-leaf manual, only a record of results and answers to questions need be written, and this should not take more than one-fourth of the laboratory time. Questions should not be answerable by "yes" or "no," and the answer should always be so worded as to include the question.

In a general discussion the following suggestions were offered:

The crowding around the supply shelves in large classes may be avoided by setting out from four to eight bottles or beakers full of the various materials needed, especially of those used at the beginning of the experiment.

The weighing of materials for most experiments may be avoided by using such measures as spoons, clay pipe bowls, test tubes, etc.

The paper, "Chemistry for Girls Should be Modified How?" by Mr. W. T. Heilman, formerly at North High School, Columbus, Ohio, was read by Dr. A. L. Smith.

Summary.—The chemistry for girls should not be modified in order to make the work easier, but rather to relate the work more closely to the daily life of the girl and the woman to be. There should be a reasonable development of the theory of chemistry with as much emphasis as possible on the applications of chemistry in daily life. One effect of such modification of the chemistry offered girls is shown by the increase in the number of girls studying chemistry in North High School from five in 1906 to 180 in 1917. The following outline of topics used in the girls' classes at North High School was prepared by a committee of teachers in 1915.

First Semester.

1. Physical changes; chemical action and the results; elements, compounds; matter and energy.
2. Water: its composition and uses with a special study of its solvent power; methods of purification for drinking purposes; hydrogen peroxide.
3. Preparation and properties of oxygen; oxidation; combustion and heat.

4. Preparation and properties of hydrogen; reduction and some of its simpler applications.
5. Gas laws: standard conditions; simple problems to illustrate the laws.
6. Combining weights and the atomic theory; valence.
7. Formula weights; equations; calculations.
8. Acids, bases, and salts; neutralization; ionization.
9. The atmosphere; air and ventilation; carbon dioxide.
10. Nitrogen and the nitrogen compounds; sources of the more important nitrates and their uses; nitric acid.
11. Sulphur and its compounds.
12. Equilibrium.
13. The periodic law.
14. Chlorine, its properties and uses; bleaching powder.
15. Hydrochloric acid; sources and uses of the more important chlorides.
16. Molecular weights; atomic weights.

Second Semester.

17. Metals; general methods of metallurgy; a study of the more important uses and properties of the following: iron, zinc, tin, copper, aluminum, nickel, lead, gold, silver, alloys, and amalgams.
18. Sodium and potassium and their more important compounds.
19. Fuels; flames; electric furnaces.
20. Hydrocarbons; substitution products; alcohols, aldehydes, and esters.
21. Carbohydrates: cellulose, nitro-cellulose, starch, dextrin, the sugars, the aromatic series.
22. Foods: purpose, fundamental sources, classification, composition, measures of food values, quantity and kinds required, and the balanced ration.
23. The chemistry of cooking; adulteration and preservation of foods; substitutes; baking powders, breadmaking, milk, cheese, cream, butter, and oleomargarine.
24. Cleaning and laundering: removal of stains, bleaching, bluing, soaps and washing compounds.
25. Textiles; dyes and dyeing.
26. A study of some common substances such as aluminum oxide, sandstone, emery, silicon carbide, silica, the alums, zinc white, white lead, iodine, and such others as may suggest themselves to the teacher or as time will permit.

The work in the classroom is based largely on what is done in the laboratory. Following is a list of experiments from which laboratory exercises are chosen. From thirty-six to forty-five of these are performed by the pupils and carefully studied and written up, after which a discussion and a quiz is held.

List of Laboratory Exercises.

First Semester.

1. Physical and chemical changes.
2. Elements and compounds.
3. Preparation and properties of oxygen.
4. Preparation and properties of hydrogen.
5. Compounds formed in the preparation of hydrogen.
6. Simple test for the impurities in water.
7. Distillation.
8. Water of crystallization. Qualitative.

9. Solubility of gases.
10. Solubility of liquids.
11. Relative solubility of solids and effect of heat on the solubility of solids.
12. Thermal phenomena of solution.
13. A study of acids, bases, and salts.
14. Neutralization. Quantitative.
15. A study of ammonium compounds.
16. Preparation and properties of ammonia.
17. Preparation and properties of nitric acid.
18. Sulphur and some of its compounds.
19. Preparation and properties of hydrogen sulphide.
20. Sodium and potassium and their more important compounds.

Second Semester.

21. The alkaline earth family.
22. Aluminum compounds.
23. Iron compounds.
24. Charcoal and some of its uses.
25. Preparation of carbon dioxide and its properties.
26. Baking powders.
27. Hard waters.
28. Bleaching powders.
29. Starches.
30. A study of sugars.
31. Preparation of sugar from starch. Invert sugar.
32. A study of fibers used in clothing.
33. A brief study of dyes and their relation to the kinds of fiber.
34. Stains, and how to remove them.
35. A study of toilet and laundry soaps.
36. Milk tests for detecting adulteration and preservatives.
37. Butter and butter substitutes.
38. Food preservatives.
39. Acidity of lemons and other fruits.
40. Water of crystallization. Quantitative.

The following supplementary list is used from which to select exercises to be substituted for some of the above when it seems best.

1. Preparation of soluble salts.
2. Preparation of insoluble salts.
3. Preparation of metallic sulphides.
4. Preparation of nitrous oxide.
5. Preparation of nitric oxide.
6. Fermentation.
7. Examination of different brands of table salt.
8. Examination of different brands of baking powders.
9. Examination of different brands of vinegar.

Discussion.—Dr. Albert L. Smith, Englewood High, Chicago: The classes are segregated at Englewood. The girls are given the same work on fundamentals during the first semester, as the boys. During the second semester, the girls get more work along food, textile, and allied lines, than the boys do.

Mr. Tydeman, Ottawa High School: Better results can be secured with segregated classes. Mr. Heilman has outlined too much work in his paper. Most of the work with metals must be omitted with girls' classes on account of lack of time. During the first semester the girls should be given the same work on fundamentals as the boys. The gas laws might be omitted in girls' classes.

Mr. Geo. Sype of Austin High, Chicago, said that he omitted the gas laws in the girls' classes.

It was moved and seconded that the Chair appoint a committee of three to act as a Lookout Committee to organize the work of the section, trying especially to make each member of the section do some work. Carried.

Mr. Osborne then resigned in favor of the new Chairman, Mr. Wilson, so that the latter might appoint this committee. The following committee was chosen:

H. R. Smith, Lake View High School, Chicago.
R. W. Osborne, Francis Parker School, Chicago.
A. L. Smith, Englewood High School, Chicago.

There being no further business, the meeting was adjourned.

H. M. Mess,
Secretary pro tem.

MINUTES OF THE HOME ECONOMICS SECTION OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The meetings of the Home Economics Section were held in Emmons Blaine Hall, Room 390, School of Education, University of Chicago. The first session was called to order at 1:30 p. m., Friday, November 29, 1918, by the Vice-Chairman, Miss Katherine May Hardy of Steel High School, Dayton, Ohio.

The following Nominating Committee was appointed and asked to report at the Saturday morning session: Miss Beatrice Hunter, University of Chicago; Miss Treva Kauffman, Ohio State University; Mrs. Helen M. Sabin, Carl Schurz High School, Chicago.

Cards were passed for registration and membership in the Central Association.

The first paper of the meeting was given by Mrs. Helen M. Sabin of Carl Schurz High School. It dealt with "Food Conservation Work at the Municipal Pier" in Chicago.

The second paper on "Textile Problems of Today" was presented by Miss Sarah A. Sutherland of the University of Illinois.

Miss Beatrice Hunter, University of Chicago, read a report from the Committee on "High Schools of Tomorrow."

In the absence of Miss Frances Swain of Chicago Teachers' College, Miss Jennie Snow, Supervisor of Home Economics in the city of Chicago, led the discussion which followed these papers. She spoke of the inspiration left us by Ellen Richards, of her vision for the future of science as it might be applied to simplify the problems of the home. Our ideals of today will determine the schools of tomorrow. We must guard against dropping back since the unusual demands made upon us by war time conditions are removed.

The question arose whether general science and special courses had been taking over material from the field of home economics, and as to ways of avoiding duplication in material taught. It was asked if it seemed permissible for general science classes to use home economics laboratories. Is it advisable for home economics teachers to take charge of general science classes? Is home economics applied economics or applied science?

Miss Snow felt there is no need to worry lest science should steal home economics material. The general science courses and special sciences have drawn from the realm of home economics in order to vitalize their special work, but the field of material is too vast to exhaust.

Our problem is to make science teaching really function, to make our teaching vitalize the sciences. Discussion showed a feeling that recent war work has strengthened the relation between school and home. Mothers have sent the problems of home to the school. They have seen that the school can really do some things for the girl which the mother never could do.

Before the session adjourned Dr. Blunt announced that Mrs. Forbes Robertson Hale would speak at 4:30 p. m. on the subject of "The World-Wide Relief Program, Which the United States Government Is Carrying On."

SATURDAY, NOVEMBER 30, 10 P. M.

The meeting was called to order by Miss Hardy. The program opened with a paper by Dr. Katherine Blunt of the University of Chicago on "How to Make the Educational Work of the Food Administration Lasting." Dr. Blunt believes that a science course to be vital must, at the present time, somehow feature health. Discussion following her paper emphasized the thought that the important question for home economics teachers to decide in this connection is: How can we make the home economics work in the schools help to raise the standards of health?

Upon motion the Chairman was authorized to appoint a committee of four to study this matter, to make an outline for the use of home economics teachers in this work, and to write letters to school officials drawing attention to it in order to get some definite action.

In the discussion which followed Dr. Blunt's paper, Miss Winkleman of Lewis Institute voiced the feeling that it would be helpful if a clear statement of fundamental diets could be put up where people could easily see them, to use in a choice of meals, especially in public eating places. It was suggested that teaching has been short on selection, both for rich and poor. Selection should be emphasized rather than manipulation.

Miss Hunter stated that in connection with the foods work at the University of Chicago, a minimum of time is being given to manipulation, and stress is being placed on selection and purchase of both food and clothing.

Miss Kauffman of Ohio State University suggested the use of the Langworthy classification printed on large cards.

Mrs. Adams of Ohio State University felt that in the matter of sanitation in the coming health program, a great burden would rest upon the smaller towns and villages where sanitary conditions are usually very poor because there is no one to enforce health laws, and public sentiment is hard to create in sufficient strength to bring about a better state of affairs.

The question arose as to how a home economics teacher can tactfully do her work in sanitation in the small town. It was suggested that aside from influencing the homes and foods stores through her pupils she might work in cooperation with any of the women's clubs or organizations in the community. Physiology taught through the grades is the backbone of sanitation teaching. The emphasis should be social. We should see that pupils have personal and social hygiene.

Teachers of the various sciences should cooperate with each other so that there would be a close interrelation in the science work of the pupils.

Miss Kauffman suggested that "Cooperation" would be the prevailing thought for the next Association meeting.

Miss Laura Winkleman presented a paper on the "Dietetic Demands of Today."

A business meeting was then called. The Nominating Committee presented the following names as officers of the Home Economics Section for the year 1919:

Chairman—Dr. Katherine Blunt, University of Chicago.

Vice-Chairman—Miss Mary Edmunds, Michigan Ag. College, Lansing, Mich.

Secretary—Miss Grace Hood, University of Cincinnati.

Upon motion the report of the committee was adopted and the Secretary instructed to cast the ballot for these names as officers.

The Chairman then announced her appointment of the following committee on the matter of helping to raise health standards through home economics teaching: Miss Grace Hood, University of Cincinnati; Miss Laura Winkleman, Lewis Institute; Miss McAuley, of Chicago; Miss Sarah Sutherland, University of Illinois.

The meeting then adjourned.

BUY FIFTH LIBERTY BONDS AND BE SAFE.

About the saddest thing in the world is to undergo self-denial for years, to save money, and then to see the "rainy day fund" wiped out by the failure of some "wild cat" scheme.

This happens every day. Widows and hard-working men are credulous. They listen to the oily promises of "get rich quick" promoters and hand over their savings to slick salesmen with "blue sky" securities promising impossible profits.

And when the bolt falls out of the clear sky the pitiful savings of years disappear in an instant. "The Bonanza Patroil Co. has gone up. We are ruined!" Then there is nothing to do but begin life all over—and at a time when earning capacity has begun to ebb and the way is thornier than ever before.

Whatever the temptation may have been in the past to do this thing, there is no excuse for it now. Hundreds of thousands of experienced publicity and investment men have been at work for nearly two years, under the authority of the American Government, educating millions of people in the fine art of safe investing. It is undoubtedly the fact that more people are saving money today than ever before in all the history of the world. And more of the people are interested in the proper handling of their savings accumulations. Literally millions have been taught to buy Government bonds, and they have learned to buy Thrift and War Savings Stamps as the best possible way to prevent the waste of fugitive quarters and dimes.

The Government will offer another chance to "get in on the ground floor" during the spring when the Fifth Liberty Loan is offered. The money will be spent to pay the cost of maintaining and restoring to their homes the valiant soldiers who have won for America the world's greatest victory. The bills must be paid and the American people must pay them.

From the "thrift and savings" viewpoint the Fifth Liberty Loan will be as good as, or even better than, the previous Liberty Loans. It is likely to have a shorter maturity and that will enable the holder to obtain a generous income while he holds them and get his principal back, with a handsome appreciation during the coming period of intense activity and prosperity.

If anything "goes up in value" Liberty bonds surely will. The way to get the benefit of such advances in value is to buy the coming Fifth Liberty bonds.

Set aside all the money you can spare out of your wages and have it in your savings bank for the initial payment on Fifth Liberty bonds.

PROBLEM DEPARTMENT.

Conducted by J. O. Hassler,
Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. O. Hassler, 2337 W. 108th Place, Chicago.

SOLUTION OF PROBLEMS.

Arithmetic.

591. *Proposed by Daniel Kreth, Wellman, Iowa.*

A boy bought twenty lead pencils for twenty cents; some for four cents each, some for one-half cent each, and some for one-fourth cent each. How many of each did he buy? Solve by arithmetic.

I. *Solution by Wm. B. Borgers, McKinley High School, Chicago.*

To make the total cost twenty cents there must be less than five four-cent pencils. But there must be more than two, for if there were only two, the remaining eighteen would cost less than nine cents. This reduces the problem to a trial of three, then four, four-cent pencils.

Trying four, we are restricted to multiples of four for both other kinds, thus:

4 cents.	1/2 cent.	1/4 cent.	Total cost.
4	4	12	21 cents.
4	8	8	22 cents.
4	12	4	23 cents.

Trying three restricts us to odd half-cent pencils and odd multiples of two-for-quarter-cent pencils.

3	3	14	17 cents.
3	7	10	18 cents.
3	11	6	19 cents.
3	15	2	20 cents.

Hence, there were three four-cent, fifteen half-cent, and two quarter cent pencils.

II. *Solution by R. T. McGregor, Elk Grove, Cal., and M. G. Schucker, Pittsburgh, Pa.* (Alligation Alternate.)

Since the twenty pencils cost twenty cents, the average cost of a pencil is one cent. If a boy buys a pencil for four cents and the average price is one cent, he loses three cents, and to lose one cent he must therefore buy one-third of a pencil. If he buys a pencil for a half cent, he gains one-half cent, and to gain one cent he must buy two pencils. If he buys one for one-fourth cent he gains three-fourths cent, and to gain one cent he must buy four-thirds pencils. Now, in order that gains and losses shall balance, he must lose another cent, and so buy another one-third pencil at four cents.

4	1/3	1/3	5	1	6	3
1/2	2		30		30	15
1/4		4/3		4	4	2

Multiplying the second column by 15 and the third by 3, and adding the two loss numbers, and then dividing by 2, we find that three pencils at four cents, fifteen at one-half cent, and two at one-fourth cent must be bought.

Also solved by C. E. GITHENS, R. M. MATHEWS, A. PELLETIER (*Philomathe*), *and* WALTER R. WARNE.

Algebra.

592. *Proposed by Walter R. Warne, Dickinson College, Carlisle, Pa.*

Solve:

$$9(x+y)^{\frac{1}{3}}/8y+9(x+y)^{\frac{1}{3}}/8x = 8/7 \qquad (1)$$

$$7(x-y)^{\frac{1}{3}}/4y-7(x-y)^{\frac{1}{3}}/4x = 1/9 \qquad (2)$$

[Alsop's *Treatise on Algebra* (1857).]

Editor's Note: No person made a complete solution of this problem, including imaginary roots and checking for extraneous roots. We publish two partial solutions which we consider a credit to their authors because of the methods used.

I. *Solution by S. H. Parsons, Paris, Can., and R. T. McGregor.*

For $x+y$ write a^3, and for $x-y$ write b^3; then $x = (a^3+b^3)/2$ and $y = (a^3-b^3)/2$.

Then (1) becomes

$$9a/4(a^3-b^3)+9a/4(a^3+b^3) = 8/7,$$

which will give

$$2a^4/(a^6-b^6) = 32/63 \qquad (3)$$

and (2) becomes

$$7b/2(a^3-b^3)-7b/2(a^3+b^3) = 1/9$$

which will give

$$2b^4/(a^6-b^6) = 2/63 \qquad (4)$$

Dividing (3) by (4) we have

$$2a^4/(a^6-b^6)\times(a^6-b^6)/2b^4 = 32/63\times 63/2$$

which gives $a = 2b$.

Substituting in (3) we have $b^2 = 1$; $b = \pm 1$, $a = \pm 2$. These values give

$$x = \pm 9/2,\ y = \pm 7/2.$$

II. *Solution by Wm. B. Borgers, McKinley High School, Chicago.*

Multiplying (1) by 8/9,

$$(x+y)^{\frac{1}{3}}/y+(x+y)^{\frac{1}{3}}/x = 64/63 \qquad (3)$$

Multiplying (2) by 4/7,

$$(x-y)^{\frac{1}{3}}/y-(x-y)^{\frac{1}{3}}/x = 4/63 \qquad (4)$$

Multiplying (3) and (4) by xy,

$$(x+y)^{\frac{4}{3}} = 64xy/63,\quad (x-y)^{\frac{4}{3}} = 4xy/63$$

Hence,

$$(x+y)^{\frac{4}{3}} = 16(x-y)^{\frac{4}{3}},\text{ or } (x+y)^{\frac{1}{3}} = \pm 2(x-y)^{\frac{1}{3}} \qquad (5)$$

$$x+y = 8x-8y \quad\text{or}\quad 8y-8x,\qquad y = \tfrac{7}{9}x \text{ or } \tfrac{9}{7}x$$

Hence,

$$x = \pm 7/2,\ y = \pm 9/2;\ \text{or } x = \pm 9/2,\ y = \pm 7/2.$$

III. *Remarks by the Editor.*

The Proposer points out the possibility of complex roots but does not conclude the solution. It is true that Equation (5) in Solution II may be

$$(x+y)^{\frac{1}{3}} = \pm 2(x-y)^{\frac{1}{3}} \qquad (5)$$

or

$$(x+y)^{\frac{1}{3}} = \pm 2i(x-y)^{\frac{1}{3}} \qquad (5')$$

where $i = \sqrt{-1}$. Using equation (5′) instead of (5), we obtain

$$y = (63+16i)x/65,\ \text{or } y = (63-16i)x/65,\quad (63\pm 16i)x/65$$

whence

$$x = \pm 63^{\frac{3}{2}}/2\cdot 65^{\frac{1}{2}}(8+i),\qquad y = \pm 63^{\frac{3}{2}}(8+i)/2\cdot 65^{\frac{3}{2}}$$

or

$$x = \pm 63^{\frac{3}{2}}/2\cdot 65^{\frac{1}{2}}(8-i),\quad y = \pm 63^{\frac{3}{2}}(8-i)/2\cdot 65^{\frac{3}{2}}.$$

These roots all check.

Also solved by Jerome Burtt, C. E. Githens, G. I. Hopkins, C. P. Lancaster, John E. Lung, R. M. Mathews, A. Pelletier (*Philomathe*), M. G. Schucker, *and the* Proposer (*2 solutions*).

593. *Proposed by Walter R. Warne, Dickinson College, Carlisle, Pa.*

Solve:

$x^2+xy+y^2 = 37$ (1)

$x^2+xz+z^2 = 28$ (2)

$y^2+yz+z^2 = 19$ (3)

[Haddon's *Rudimentary Algebra* (1855).]

I. *Solution by Jerome Burtt, Adelphi Academy, Brooklyn.*

Subtracting equation (2) from (1),

$xy-xz+y^2-z^2 = 9$, or

$(y-z)(x+y+z) = 9$ (4)

Subtracting (3) from (2), we obtain in a similar manner

$(x-y)(x+y+z) = 9$ (5)

Dividing (4) by (5),

$(y-z)/(x-y) = 1$, whence $y = (x+z)/2$.

Substituting this value in (3), we obtain

$x^2+4xz+7z^2 = 76$ (6)

Multiply (6) by 7, (2) by 19, and subtract, and we have

$12x^2-9xz-30z^2 = 0$,

whence,

$x = 2z$, or $-5z/4$, and $x, y, z = \pm 4, \pm 3, \pm 2$ or $\mp\frac{10}{3}\sqrt{3}$, $\mp\sqrt{\frac{1}{3}}$, $\pm\frac{8}{3}\sqrt{3}$.

II. *Solution by M. G. Schucker, Pittsburgh, Pa.*

Add equations (1) and (2), subtract (3):

$2x^2+xy+xz-yz = 46$ (4)

From the product of equations (1) and (2), subtract the square of (4), divide through by 3, and extract the square root of the resulting equation. We have

$xy+xz+yz = \pm 26$ (5)

Take the half sum of (1), (2), (3), and three times (5), and extract the square root.

$x+y+z = \pm 9$ or $\pm\sqrt{3}$. (6)

From the half sum of equations (1), (2), (3), and (5) subtract equation (3).

$x^2+xy+xz = 36$ or 10 (7)

Divide (7) by (6) and $x = \pm 4$ or $\mp 10\sqrt{3}/3$

Similarly, $y = \pm 3$ or $\mp\sqrt{3}/3$

and $z = \pm 2$ or $\pm 8\sqrt{3}/3$.

Also solved by Wm. B. Borgers, G. I. Hopkins, John E. Lung, R. M. Mathews, S. H. Parsons, A. Pelletier (*Philomathe*), M. G. Schucker *and the* Proposer.

Geometry.

594. *Proposed by Harris F. MacNeish, College of the City of New York.*

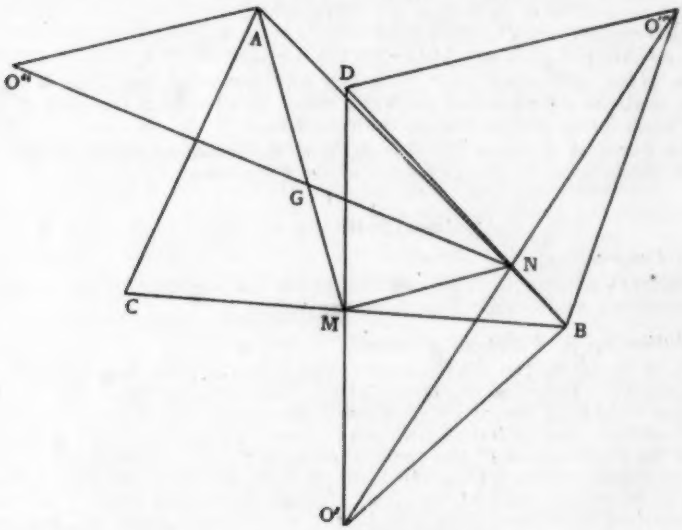
If on the sides of any triangle there are constructed outward (inward) regular polygons of the same number of sides, the triangle whose vertices are the centers of the three polygons has the same median point as the original triangle.

Solution by A. Pelletier (Philomathe), 311 St. Denis St., Montreal.

Given the triangle ABC, and O′, O″, O‴ the respective centers of the regular polygons. Let M be the midpoint of BC and N that of O′O‴. It is sufficient to prove that AM and O″N meet at a point G so that AG = 2GM, and O″G = 2NG. Join O′M and produce to D, making MD = O′M; also join BO′, BD, BO‴, DO‴.

Because ∠DBO‴ = ∠CBA, and BD, BO‴ are respectively proportional to BC, BA, the triangles O‴BD and ABC are similar, and O‴D equals the radius AO″, and is parallel to it, since ∠CAO″ = ∠ABO‴.

Now, O‴D = 2MN, hence, AO″ is parallel to MN and equals 2MN. Therefore, AG = 2GM and O″G = 2NG.



A solution by Analytic Geometry was sent in by the PROPOSER.

595. *Proposed by C. E. Githens, Wheeling, W. Va.*

Given the base, difference of the angles at the base, and difference of the remaining sides, to construct the triangle. What condition would make the solution impossible?

I. *Solution by Harris F. MacNeish, College of the City of New York.*

Given c, $a-b$ and A − B to construct the triangle.

Take AB = c as base. At A draw AD making angle BAD = (A − B)/2. With B as a center and a radius equal to $a-b$, strike an arc cutting AD at D and D′.

(Draw BE = h = $c\sin(A-B)/2$, the perpendicular from B to AD. If $a-b \gtreqless h$, or $a-b > c$, the problem has no solution. There is also no solution if $a-b$ and A − B are of opposite sign.)

Extend BD and at A draw ∠DAC equal to ∠ADC. Triangle ABC is the required triangle. Since ADC is an isosceles triangle with AC = b, therefore BC = $b+(a-b) = a$ and ∠CDA = (A − B)/2 + B = (A + B)/2. Therefore ∠CAB = (A + B)/2 + (A − B)/2 = A.

Extend D′B and construct ∠D′AC′ = ∠AD′C′. The triangle ABC′ is the solution if $a-b$ and A − B are negative.

II. *Solution by Walter R. Warne, Dickinson College, Carlisle, Pa.*
Construction:

Draw AB = given base. Construct ∠BAP = given difference of base angles. Bisect ∠BAP by AD. From B let fall a perpendicular, BD, on AD. Produce DB to F, indefinitely far away. At B in DF erect the indefinitely long perpendicular BH. With radius AG = given difference of remaining sides of required triangle describe an arc cutting BH in G, say. Prolong AG to cut BF in E, say. C, the middle point of GE, is the third vertex of the required triangle ABC.

Demonstration:

∠HBE = 90°. With C as a center a circle may be described through S, B, E. Therefore, GC = CE = CB. Therefore, AC − CB = AC − CG

$=AG$. $2\angle DAB$ (or $\angle PAB$) $= 2(90° - \angle ABD) = 180° - 2\angle ABD = 180° - 2(\angle CAB + \angle AED)$.
Now $\angle ABD = \angle CAB + \angle AED$.
$\angle ACB = \angle AED + \angle CBE = 2\angle AED$, whence
$2\angle DAB = 180° - 2\angle CAB - \angle ACB =$
$\angle CAB + \angle ACB + \angle ABC - 2\angle CAB - \angle ACB = \angle ABC - \angle CAB$.

The given difference may be taken any quantity less than a right angle, and the difference of the sides must be such that the sum of the sides when found will be greater than the base.

Also solved by Fannie W. Boyce, Wm. B. Borgers, S. H. Parsons, M. G. Schucker, A. Pelletier, *and the* Proposer.

Another Solution of 574.

574. *Proposed by N. P. Pandya.*

Construct a triangle ABC, having given the distance of its incentre, circumcentre, and orthocentre from the vertex A.

Solution by A. Pelletier, Montreal.

Let O, I, H be the circumcenter, the incenter, and the orthocenter, respectively. Describe the circle ABC. The perpendicular, OE, to BC is equal to AH/2, hence BC is known, also angle A. The radius, r, of the inscribed circle is found graphically from $r = AI \sin A/2$. To locate I find the intersection of the two following loci: XY parallel to BC and at a distance r from it; also, the segment BIC, in which the known angle BIC, or $90° + A/2$, may be inscribed. The intersections I and I′ give two symmetrical solutions. Join I or I′ to the midpoint of arc BC, and produce to meet the circle at A.

Solutions of 586, 588, *and* 590 *were received too late for acknowledgment in last issue from A. MacLeod, Aberdeen, Scotland.*—[Editor.

PROBLEMS FOR SOLUTION.

Algebra.

606. *Proposed by Daniel Kreth, Wellman, Ia.*

What six numbers in geometrical progression are those of which the sum of the extremes is 99 and the sum of the other four terms 90?

607. *Proposed by M. H. Pearson, Sidney Lanier High School, Montgomery, Ala.*

A man sent four men out with 20, 40, 60, 80, and 100 apples, respectively, asking that each one sell some at one fixed price and the rest at another, and that each man collect exactly one dollar. Find the two prices.

Geometry.

608. *Selected.*

Construct a circle through a given point tangent to two fixed circles.

609. *Proposed by Harris F. MacNeish, College of the City of New York.*

Through a given point draw a straight line cutting a given straight line and a given circle such that the part of the line between the point and the given line may be equal to the part within the given circle. (Phillips and Fisher: *Plane Geometry, Ex. 50*).

610. *Proposed by Murray J. Leventhal, Stuyvesant High School, New York City.*

From a point O in an equilateral triangle ABC the distances to the vertices were measured and found to be OB = 3, OC = 4, OA = 5. Find the area of the triangle.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warne & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10169 Wilbur Ave., Cleveland, Ohio.

QUESTIONS AND PROBLEMS FOR SOLUTION.

317. *Proposed by J. C. Packard, Brookline, Mass.*

An automobile, weighing with load 1,000 lbs., while running at the rate of 5 miles an hour collides with a telegraph pole. The fender is crushed in about 2 inches. How heavy a blow did the auto deliver?

[Query: Is this the piledriver problem in another form?—Editor.]

318. *Proposed by Hanor A. Webb, Nashville, Tenn.*

The atomic weight of the gas helium is 4. In discussing the use of this gas as a substitute for hydrogen in balloons, the *Scientific American* has recently correctly stated that helium is twice as heavy as hydrogen. Explain this apparent discrepancy.

The following college entrance examination in chemistry was submitted by Dr. Lyman C. Newell:

319. (*a*) Would the use of such a set of questions—which is plainly simpler than those of the College Board—be as satisfactory as the longer and more rigid questions now seen on those examinations?

(*b*) Is there sufficient stress laid upon:

(1) Practical processes. If not, what additions?

(2) Problems. Are the problems of the right kind?

(3) Equations. Has sufficient stress been laid on equations?

320. Solve the problem marked 320 under III.

321. Solve the problem marked 321 under III.

Examinations for Admission at Boston University.

(*Time: One Hour, Thirty Minutes.*)

Group I. (*Answer Two Questions in This Group.*)

1. Describe the process of manufacturing water gas.
2. Explain fully: "Thermit is used in welding."
3. Describe the process of manufacturing one of the following: (*a*) Calcium, (*b*) aluminum.

Group II. (*Answer One Question in This Group.*)

1. Define electrolytic dissociation. Illustrate it. Write an equation showing electrolytic dissociation.
2. How is gold purified by electrolysis?

Group III. (*Solve One Problem in This Group.*)

320. Calculate the formula of a compound, 0.84 gm. of which contain 0.587 gm. of iron and 0.253 gm. of oxygen.

2. A candle weighing 50 gm. consists of wax composed of 88 per cent carbon and 12 per cent hydrogen. What weight of carbon dioxide and water will be formed by burning half the candle?

321. If 2 gm. of potassium chloride yield 3.84 gm. of silver chloride, what is the atomic weight of potassium?

(Note.—At. wts.—Iron 56, oxygen 32, carbon 12, chlorine 35.5, silver 108.)

Group IV. (*Answer Two Questions in This Group.*)

1. Describe an experiment you performed to prepare nitrous oxide. Sketch the apparatus. Write the equation for the reaction.
2. Describe an experiment to find one of the following: (*a*) The weight of a liter of oxygen; (*b*) the equivalent weight of a metal.
3. What is the test for (*a*) $Sn{+}{+}$, (*b*) a nitrate, (*c*) mercury, (*d*) sodium hydroxide, (*e*) vinegar, (*f*) $OH-$?
4. Describe an experiment to illustrate one of the following: (*a*) Catalysis; (*b*) supersaturation; (*c*) hydrolysis.

Group V. (*Answer Three Questions in This Group.*)

1. (*a*) Complete and balance $Pb(NO_3)_2 + - = PbCrO_4 + KNO_3$. (*b*) Why is HCl the formula of hydrochloric acid gas?

2. (*a*) Name three kinds of food rich in protein. (*b*) Of what use is protein food?

3. (*a*) State the use of each of the following: (1) cream of tartar, (2) silica, (3) muriatic acid. (b) Explain efflorescence.

4. Write 50 words on (*a*) the manufacture of nitric acid from the air, or on (*b*) paint.

TESTS IN CHEMISTRY.

New name on the list for chemistry tests: Louise Schweitzer, South High School, Grand Rapids, Mich.

Try the following test in Chemistry and propose a time:

UNION SCIENCE TESTS.

(*Copyright 1918. F. T. Jones.*)

Time .... min.

Test C6. Meaning of Chemical Symbols, Formulas, Equations.

1. Give the full meaning of the symbol, O.
(1)
(2)
(3)

2. Give the full meaning of the formula, H_2O.
(1)
(2)
(3)
(4)
(5)
(6)

3. Give the full meaning of the equation,

$$\underset{117}{2NaCl} + \underset{98}{H_2SO_4} -> \underset{73}{2HCl} + \underset{142}{Na_2SO_4}$$

(1)
(2)
(3)

No. 12. Attempts .... Right .... Wrong ....

SOLUTIONS AND ANSWERS.

302. What do you think of the following test in general science, especially Part II?

Answer by a 14-year-old boy who a year ago had studied general science 2 periods per week for 30 weeks, using Caldwell & Eikenberry's General Science.

"I wrote the answers to Part II in about 3 minutes. The first one was hard for me because we never monkeyed with a barometer. It was pretty easy. I got thirty-four fortieths correct."

UNIVERSITY HIGH SCHOOL.

General Science—Part I.

Answer all questions in order. Each question counts 15 points.

1. Why is a room cooled more rapidly if a window is opened at the top than when opened at the bottom? Would the change of air be more or less rapid if the window were opened at both the top and bottom? Why?

2. Explain, using a drawing if you think it will help you in the explanation, how a simple mercury barometer is made. How does it work?

3. How does yeast cause bread to rise? Explain fully.

4. How are carbohydrates made in the leaf blade, and what are four parts of the blade which take part in its manufacture?

5. Name three important gases of the air. How may one of these be made in the laboratory?

6. Tell about two experiments performed in the laboratory which prove to you that air is matter.

General Science—Part II.

There are forty blank spaces in the paragraphs that follow. To complete each statement write the proper word in the blank space. In

several cases one of several words may be used. Each word correctly written counts 1-2 point.

1. Air pressure is measured by means of a .... There are two kinds: .... and .... If either of these instruments is taken up in an aeroplane it will show a *lower* pressure than at sea level. If carried into a deep mine it will show a *higher* pressure. On a fair day the pressure is *higher*, while on a rainy day it is *lower*.

2. The instrument which is used to take the temperature of the air is called *thermometer*. There are two kinds: *Centigrade* and *Fahrenheit*. We commonly use the *Fahrenheit* kind on which the average temperature of a living room should be approximately *70* degrees and the normal temperature of the body is *98.6* degrees.

3. Air *rises* when heated and *falls* when cooled. Therefore warm air will *rise* from the warm ground because the cold air has a *greater* weight. The air is warmer in summer than in winter because the rays of the sun strike the earth more *perpendicularly* in summer. Also the days are *longer* in winter than in summer.

4. In a cloud from which rain is falling the .... is .... per cent. If the temperature is below 32 degrees F. the water vapor will come out of the air in the form of *snow*. If the temperature is above 32 degrees F. the water vapor will come out in the form of *rain*. When the air is nearly saturated and the air is then cooled a *cloud* will appear.

5. Winds blow from an area of *high pressure* to an area of *low* pressure. The velocity of the wind depends upon the *difference* of the pressures. A cyclone occurs in a *low* pressure area. If the wind sets in from the south or southeast and the air pressure is decreasing a *storm* is approaching from a *northerly* direction. A south wind from the Gulf has a *high* humidity and often brings rain because it is *cooled* as it comes north.

6. Of the three forms of matter the molecules are farthest apart in the *gaseous* form. The gases in the air do not separate into layers according to their weights because they *mix*. An *atom* is smaller than a molecule, and a molecule of water is composed of two *atoms* of *hydrogen* and one of *oxygen*.

7. Plants which do not contain chlorophyll are called .... plants. Of the three kinds of plants which occur in the air *bacteria* causes milk to sour.

ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany, for February; *Brooklyn Botanic Garden, Brooklyn, N. Y.; $5.00 per year, 60 cents a copy:* "Crytandreae Hawaiienses, Sections Schizocalyces Hillebr. and Chaetocalyces Hillebr," Joseph F. Rock; "The Ecologic Foliar Anatomy of Some Plants of a Prairie Province in Central Iowa," Ada Hayden.

Americans Mathematical Monthly, for February; *W. D. Cairns, 27 King St., Oberlin, Ohio; $3.00 per year, 35 cents a copy:* "On Certain Constructions of Descriptive Geometry," G. Loria; "Difference Quotients," J. P. Ballantine; "A Theorem in the Geometry of the Triangle," J. W. Clawson; "On an Elementary Problem of Closure on an Equilateral Hyperbola," A. Emch.

General Science Quarterly, for January; *Salem, Mass.; $1.25 per year, 35 cents a copy:* "General Science in the Junior High Schools of Massachusetts," W. G. Whitman; "The Making of a Match: A Project," Charles H. Stone; "Code of Lighting School Buildings," Committee of Expert Illuminating Engineers; "The Project of a Frozen Water Pipe," John Francis Woodhull; "An Introductory Lesson, Leading to a Study of Science About the Home," Dessie P. Spangler; "Some Suggestions for the Study of Our Food Supply," Marion D. Weston.

Geographical Review, for January; *Broadway at 156th St., New York City; $5.00 per year, 50 cents a copy:* "The American Geographical Society's Contribution to the Peace Conference" (one insert map); "The Enchantment of the Old Order" (fourteen photos), Alice Tisdale;

"The Future of Palestine" (one map), Ellsworth Huntington; "Geography in America," Wallace W. Atwood; "Rainy Days and Rain Probability in the United States" (two maps), Robert DeC. Ward.

L'Enseignement Mathematique, for December; *G. E. Stechert & Company, 151 W. 25th St., N. Y.; 20 francs per year, 4 francs a copy:* "Notions d'Arithmogéométrie (5° et dernier article)," E. Turrière; "Sur là Variété moyenne de deux variétés convexes," G. Tiercy; "Contribution à la construction des éléments doubles d'une involution hyperbolique," F. Redl; "Extraction de la racine n^{ieme} d'un nombre réel par approximations successives," M. T. Beritch; "Note sur les permutations," A. Aubry; "Sur la rectification approchée d'un arc de cercle," A. Plescot. For January: "L'approximation des fonctions d'une variable réelle," C. de la Vallée Paussin; "Deux récents ouvrages de Géométrie," A. Buhl; "Remarques sur la construction des courbes gauches avec application a la parabole cubique," G. Loria; "Théorie élémentaire de la toupie gyroscopique," M. Zack.

The Mathematical Gazette for January; *G. Bell & Sons, Portugal St., Kingsway, W. C. Q., London; 1s. 6d. net:* "Alice Through the (Convex) Looking Glass, (Concluded)" W. Garnett; "The Introduction to Infinite Series," W. J. Dobbs; "The Equilibrium of Jointed Frameworks," Prof. G. H. Bryan.

National Geographic Magazine, for December; *Washington, D. C.; $2.50 per year:* "The Races of Europe, an Account Which Removes the Padlock of Technicality from the Absorbing Story of the Mixture of Peoples in the Most Densely Populated Continent," Edwin A. Grosvenor.

Photo-Era, for February; *Boston, Mass.; $2.00 per year, 20 cents a copy:* "The Second International Salon at Los Angeles," Arthur F. Kales; "The Quest for Color (fifth of the "Professor Pyro" Talks), Michael Gross; "A Homemade Flashbag," C. A. Pierce; "Practical and Humorous Experiences in Photography," A. H. Beardsley; "The Fixing and Washing of Prints," George F. Stine.

Physical Review, for January; *Ithaca, N. Y.; $6.00 per year, 60 cents a copy:* "Ionization and Excitation of Radiation by Electron Impact in Nitrogen," Bergen Davis and F. S. Goucher; "On a Kinetic Theory of Magnetism in General," Kotaro Honda and Junzo Okubo; "On the Theory of Superposed Diffraction-Fringes," Chandi Prasad; "On the Mechanical and Electrodynamical Properties of the Electron," Megh Nad Saha; "A New Experimental Determination of the Brightness of a Black Body, and of the Mechanical Equivalent of Light," Edward P. Hyde, W. E. Forsythe, and F. E. Cady; "Ionization and Resonance Potentials for Electrons in Vapors of Arsenic, Rubidium, and Caesium," Paul D. Foote, O. Rognley, and F. L. Mohler; "Energy of the Characteristic X-Ray Emission from Molybdenum and Palladium as a Function of Applied Voltage," Benjamin Allen Wooten.

Popular Astronomy, for March; *Northfield, Minn.; $3.50 per year:* "Map of Total Eclipse Path of September 10, 1923"; "The Total Eclipse of September 10, 1923," Joaquin Gallo; "Report on Mars, No. 21, Concluded," William H. Pickering; "Twenty-second Meeting of the American Astronomical Society, Concluded"; "Saturn, the Wonder of the Worlds," John H. Thayer; "Edward Charles Pickering (with Plate XI)," Annie J. Cannon.

Scientific Monthly, for March; *Garrison, N. Y.; $3.00 per year, 30 cents a copy:* "Sources and Tendencies in American Geology," Joseph Barrell; "The Principles and Problems of Government," Dr. P. G. Nutting; "A Botanical Trip to Mexico," A. S. Hitchcock; "The Engineer's Part in After-the-War Problems," F. H. Newell; "Biological Philosophy and the War," Leon J. Cole; "Some Perils Which Confront Us as Scientists," Francis B. Sumner; "Some Problems of Gas Warfare," Dr. Ellwood B. Spear.

BOOKS RECEIVED.

Farm Science, a Foundation Textbook on Agriculture, by W. J. Spillman, U. S. Dept. of Agriculture. Pages vii+344. 14x19 cm. Cloth. 1918. $1.28. World Book Company, Yonkers, N. Y.

The War and America, by Roscoe L. Ashley. Pages viii+103. 13x19 cm. Cardboard, 1918. 60 cents. The Macmillan Company, New York City.

Commercial Tests and How to Use Them, by Sherwin Cody, Director National Associated Schools of Scientific Business. Pages vii+216. 12x18.5 cm. Paper. 1919. 99 cents. World Book Company, Yonkers, N. Y.

The Gary Public Schools, Household Arts, by Eva W. White. Pages xix+49. 13x20 cm. Paper. 1918. 10 cents. General Education Board, 61 Broadway, New York City.

Science of Plant Life, by Edgar N. Transeau, Ohio State University. Pages x+336. 14x19 cm. Cloth. 1919. $1.48. World Book Company, Yonkers, N. Y.

Proceedings of the High School Conference at the University of Illinois, November, 1918, 306 pages. 15x23 cm. Paper. 1919. University of Illinois Press, Urbana.

BOOK REVIEWS.

Trade Foundations Based on Producing Industries, by several vocational instructors and tradesmen. 16.5x23.5 cm. Cloth. 1919. The Guy M. Jones Company, Indianapolis, Ind.

Without question this is not only a very unique book, but it is a most important and timely one. It is a volume which all artisans and people interested in vocational guidance should possess. It has for its authors twenty-five men who have been selected from the various vocational lines of work for their known ability and knowledge of the subjects upon which they have written, to prepare the material in their particular lines of work. These various articles have all been coalited and embodied in this splendid volume. There are literally hundreds of half tones and drawings scattered throughout the text. These drawings have all been selected with the point in view of not only interesting the reader but of explaining the text which accompanies the drawing. The cuts are practically all new, and the reviewer has seen but few of them in print heretofore.

The book is divided into six sections as follows: "Occupations," "Material," "Tools," "Operations," "Drawing," "Prevocational Shop Work." Each author has produced from his fund of information a most carefully prepared description of work which comes under his particular calling. Each author, too, has written the descriptions, a plan of work, the theory, etc., in a clear and concise manner. It is by all odds the best text of its kind that has yet come from the press.

The mechanical work on the book is of the very highest standard. The paper is of excellent quality. The major paragraphs all begin with heavy, bold faced type, and the various divisions under each department are divided into heads. Scattered throughout the book are addresses of various firms dealing in materials mentioned in the book. Lists of tools and equipment likewise are given for practically each one of the several divisions.

In fact, the book is an encyclopedia of vocational work, and as has been said above, every vocational worker and householder should possess a copy. There is no doubt that the book will have an extensive circulation.

C. H. S.

The Waterboys and their Cousins, by Charles D. Lewis, Berea College. Illustrated with drawings by E. H. Suydam. 172 pages. 13x19 cm. $1.75. J. B. Lippincott Company.

The author has attempted to put some of the more important truths of biological science into story form, of the fairy story type. The Waterboys are molecules of water whose story forms the foundation of the book. Some other plant parts entering into the story are the "Bean Babies," "Nitrogen Bacteria," "Root Children," "Garden People," "Mother Corn," "Flower People," "Twig Babies," and a number of others. The stories are entertainingly told and the science appears to be correct so far as it is based on scientific facts. We believe that the author has been quite successful in making the child see some of the fascinating happenings of nature through the medium of the story. W. W.

CURIOUS COMPUTATIONS.

By J. C. Packard,
Brookline, Mass.

A. B. T. U. is the amount of heat required to raise the temperature of a pound of water one degree Fahrenheit.

The heat of combustion of anthracite coal averages 13,000 B. T. U. per pound.

The latent heat of melting of ice is 147 B. T. U. per pound.

One B. T. U. equals 778 foot pounds.

A cubic foot of ice weighs 57.4 pounds.

Then: To "heat the teakettle," containing a quart of water, drawn from the kitchen faucet at a temperature of 50°F., to the boiling point requires 324 B. T. U. of heat, or 252,072 foot pounds of energy, or the equivalent in foot pounds of the work required to lift the entire outfit, range and all (400 lbs.), to a height of 630 feet. Startling!

A hodful of coal (20 lb.), when burned in the kitchen range, develops enough energy (101,140 foot tons) to lift the entire house, contents and all, to a height of 100 feet. If the hodful of coal was "all burned up" within two hours energy was developed at the rate of 51 horsepower. Astounding!

The lawn in front of my house has an area of 5,000 square feet; it was at one time covered with snow to a depth of two feet; the snow melted away in a week. The heat absorbed by the snow in melting amounted to 84,378,000 B. T. U. or the equivalent of 32,823,042 foot tons of energy, enough to lift a whole block of houses to the top of a hill 100 feet high. Incredible!

A small lake near my home covers ten acres. In freezing to a depth of six inches the water gives out 1,837,752,840 B. T. U. of heat, the equivalent in heat units of 141,366 tons of anthracite coal or enough to supply the whole community for the entire winter. Munchausen!

ERRATUM.

On page 282 of the March issue in the review of "An Introduction to the Study of Science," second paragraph, third line, the word "or" should be omitted and the word "than" inserted after rather.

Fifty cents will be paid for back numbers Vol. II, No. 3, May, 1902.

SECOND CALL—NAVY NEEDS MANY MEN TO VOLUNTEER—ENLISTMENTS OPEN IN PRACTICALLY EVERY BRANCH OF THE SERVICE.

Fighting may have ceased in the war zones, but the work of the United States Navy still goes on. Soldiers must be brought back, seas must be policed, and the hundred and one other duties which fall to our Navy in peace times remain to be performed.

With the many men now being released and discharged, the problem arises as to how their places are to be filled. Hence the preparations the Bureau of Navigation is making for an intensive campaign to secure recruits for the Navy.

Practically every branch of the service is now open for voluntary enlistment, and many wonderful opportunities are being offered to men who now enter the service. Age limits range from seventeen to thirty-five. Young men seventeen years of age and who have not yet reached their eighteenth birthday may enlist with the consent of their parents.

Men over eighteen years of age who have had a limited amount of machine shop or electrical experience may enlist and attend the Navy machinist or electrical schools, where they are given a thorough and valuable education in their branch. Men are also wanted to enlist as apprentice seamen, firemen, hospital apprentices, mess attendants, cooks, machinists, and electricians.

Arrangements have been made whereby men who desire to make application for enlistment and do not live in a city having a recruiting station may be furnished free transportation to the nearest recruiting station.

Enlist now and help make our Navy the best and largest in the world. Apply to your postmaster for particulars or write direct to the Navy Recruiting Station, Transportation Building, Chicago, Ill.

DIRECTORY OF SCIENCE AND MATHEMATICS SOCIETIES.

Under this heading are published in the March, June, and October issues of this Journal the names and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society. This is extremely valuable information to all progressive teachers. Is your Society listed here? Names are dropped when they become one year old.

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CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS. (*Annual meeting, November 27, 28, and 29, 1919, at the Lake View High School, Chicago.*)

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